

**DIVISION 600 - INCIDENTAL CONSTRUCTION****SECTION 601 - STRUCTURAL CONCRETE**

**601.01--Description.** This work consists of furnishing and placing portland cement concrete for specified structures in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the plans or established by the Engineer.

Structural concrete will be divided into two groups. One group will be designated as Structural Concrete. The other group will be designated as Structural Concrete, Minor Structures. Unless otherwise specified in the contract, Structural Concrete, Minor Structures, will include inlets, catch basins, junction boxes, pipe headwalls, and pipe collars, regardless of the concrete quantity required for each of these structures; and other small structures containing less than 3.00 cubic yards of concrete each.

**601.02--Materials.**

**601.02.1--General.** Materials for structural concrete and their use, care, and handling shall be in accordance with Subsection 804.02. In addition, Type IP portland cement meeting the requirements of Subsection 701.04 will be permitted. Sampling and testing will be in accordance with Subsection 804.02.3.

**601.02.2--Classification of Concrete.** Concrete for this work shall be the class specified on the plans or in the bid schedule of the contract. Classes of concrete are identified in Subsection 804.02.6.

**601.02.3--Precast Units.** Design standards normally contemplate that structural concrete will be cast in place. However, the Contractor may request approval from the Engineer to furnish and install precast units in lieu of cast-in-place units. The request shall be accompanied by detailed drawings of the precast units and design data certified by a registered Professional Engineer as to structural and functional adequacy.

The foundation for precast units shall be carefully shaped to the precise contour and grade of the bottom of the unit before the unit is placed.

Precast units which are to be joined to other units shall be designed and manufactured with proper and adequate joints. Joints shall be sealed with a joint material meeting the applicable requirements of Section 707.

No additional payment will be allowed for precast units approved for use. Pay items and quantities will be as in cast in place in accordance with design standards.

**601.03--Construction Requirements.**

**601.03.1--Composition of Concrete.** The composition of the concrete shall be in accordance with Subsection 804.02.7.

**601.03.2--Batching.** Measuring and batching of component materials shall be in accordance with the applicable provisions of Section 804.

**601.03.3--Mixing and Conveying Concrete.** Concrete shall be mixed and conveyed in accordance with the applicable provisions of Subsection 804.03.2.

**601.03.4--Cold or Hot Weather Concreting.** Requirements for placement, protection, and curing of concrete during cold or hot weather are stipulated in Subsection 804.03.16.

**601.03.5--Consistency.** The slump of the concrete, determined in accordance with the provisions of Subsection 700.03, shall conform to the applicable requirements of Section 804.

**601.03.6--Falsework and Forms.**

**601.03.6.1--Falsework.** Falsework shall be in accordance with the applicable provisions of Subsection 804.03.13.

**601.03.6.2--Forms.** Forms shall conform to the requirements of Subsection 804.03.14.

**601.03.6.3--Removal of Falsework, Forms, and Housing.** The removal of falsework, forms, and the discontinuance of heating, shall be in accordance with the provisions and requirements of Subsection 804.03.15, except that the concrete shall conform to the following age or cylinder strength requirements:

	<b>Column A</b>	<b>Column B</b>
Wingwall and Wall Forms not Under Stress	24 to 48 hours*, minimum	1,000 psi
Wall Forms under Stress	7 days, minimum	2,200 psi
Backfill and Cover clear	3 days per foot clear span or clear height, whichever is the greater; or 10 days, minimum	2,400 psi

\* As directed by the Engineer

If Type IP cement or Type I or II portland cement plus fly ash is used, only

Column B will be applicable.

When the walls and top slab of box culverts and box bridges are not to be poured monolithically, extreme care shall be used when forming and pouring the top slab on walls in which the concrete has not attained its full design strength. In order to prevent damage to fresh concrete, either of the following methods of forming and pouring may be used:

- (a) Subject to approval by the Engineer, the wall forms and deck forms may be so constructed and separately supported and braced that the walls may be poured and the wall forms removed as for wall forms not under stress. The Engineer may require a detailed plan of the proposed method of forming for approval. When this method of forming is used, the deck forms shall be in place and adequately and independently supported throughout before pouring the walls. Deck forms shall overlay the top edge and be flush with the face of the inside wall forms, but shall not be dependent upon any part of the inside wall forms for support. The intersection of the wall and deck forms shall be mortar tight. The wall forms may be constructed slightly less than the specified inside clear height of the structure and wedged upward from the bottom of the riser wall to permit easier removal. When this method is used, the concrete in the wall shall be poured flush with the top of the deck form.
- (b) At the option of the Contractor, the walls may be formed, adequately braced, and poured before the deck forms are in place. In this case the forms may be removed as for walls not under stress. Before erecting any part of the forming for the top slab, the concrete in the walls shall have attained the age or the strength specified for the removal of wall forms under stress.
- (c) The Contractor may elect to form and adequately support and brace the wall and deck forms as a composite unit before pouring the walls. In this case the outside forms may be removed as indicated for wall forms not under stress provided adequate provisions are made for forming the outer (vertical) surfaces for the subsequent deck pour. The inside wall forms shall remain in place as indicated for wall forms under stress.

**601.03.6.4--Damage to Previously Placed Concrete.** In the event previously placed concrete is damaged, all work on the affected structure shall cease immediately for an engineering assessment of the damage and the corrective work to be performed. No additional work shall be performed until this determination has been made, and the Engineer has given the Contractor approval to proceed with the corrective work and subsequent construction. All corrective work required shall be performed by the Contractor at no additional cost to the State.

**601.03.7--Foundations and Footings.** Foundations for structures shall be prepared in accordance with the requirements and provisions of Section 206.

All footings shall be poured "dry." Where footings can be placed in the "dry" without the use of cribs or cofferdams, the Engineer may permit back forms to be omitted, and concrete poured against the faces of the excavation.

**601.03.8--Placing Reinforcing Steel.** Reinforcing steel shall be placed in accordance with the requirements of Section 602 and as shown on the plans.

**601.03.9--Handling and Placing Concrete.** Handling and placing concrete shall be in accordance with the provisions of Subsection 804.03.6.

**601.03.10--Expansion and Fixed Joints.** All expansion and fixed joints shall conform to the applicable provisions of Subsection 804.03.18.

**601.03.11--Finishing Concrete Surfaces.** Unless otherwise authorized, the surface of the concrete shall be finished immediately after form removal.

Surface finishes shall conform to the applicable provisions of Subsection 804.03.19.

**601.03.12--Curing Concrete.** Concrete shall be cured in accordance with the provisions of Subsection 804.03.17.

**601.04--Method of Measurement.** Accepted quantities of structural concrete will be measured by the cubic yard. Except for changes ordered in writing by the Engineer, the neat dimensions shown on the plans will be used for computing volumes. The quantity of concrete in fillets, scorings, and chamfers one square inch or less in cross sectional area will be neglected in measurements.

No deductions will be made for the volume of concrete displaced by reinforcement, pipe or other conduits less than eight inches in nominal diameter, pipe posts, structural steel posts, or joint material.

When both Pay Item Numbers 601-A and 601-B are included in the contract, measurement of concrete for Pay Item No. 601-B will be limited to inlets, catch basins, junction boxes, pipe headwalls, and pipe collars, regardless of the concrete quantity required for each of these structures; and other small structures containing less than 3.00 cubic yards of concrete each.

**601.05--Basis of Payment.** Structural concrete will be paid for at the contract unit price per cubic yard which shall be full compensation for completing the work.

Payment will be made under:

601-A: Class \_\_\_\_ Structural Concrete

- per cubic yard

601-B: Class \_\_\_\_ Structural Concrete, Minor Structures

- per cubic yard

## **SECTION 602 - REINFORCING STEEL**

**602.01--Description.** This work consists of furnishing and placing reinforcing steel in accordance with these specifications and in reasonably close conformity with the dimensions, bending, spacing, and other requirements shown on the plans.

**602.02--Materials.** Reinforcing steel shall conform to the requirements of Section 711 and Subsection 805.02.

### **602.03--Construction Requirements.**

**602.03.1--Bar List and Order Lists.** The bar lists and bending schedules shown on the plans are primarily for the purpose of estimating quantities. Lengths of box culverts and box bridges, and depths of inlets, etc. shown on the plans are also approximate. The Contractor shall verify the quantity, size, and shape of the reinforcement for compliance with the structural drawings and make the necessary corrections, if any, before ordering. In the case of box culverts, box bridges, inlets, etc., verification shall be made after the Engineer has furnished the Contractor with a list of the staked lengths or depths for structures. Errors in the bar list and bending schedule shall not be cause for adjustment of the contract unit price, and the Contractor shall be fully responsible for all expenses caused by the Contractor's failure to furnish the proper size, shape, length, and quantity of reinforcing steel required.

When stipulated in the contract, or at the option of the Contractor when not stipulated, order lists and bending diagrams shall be furnished to the Engineer for approval. In these cases no materials shall be ordered until the lists and bending diagrams have been approved. The approval of order lists and bending diagrams by the Engineer will in no way relieve the Contractor of the responsibility for the correctness of the lists and diagrams. All expense incident to the revision of materials furnished in accordance with such lists and diagrams to make them comply with the design drawings and lengths as staked by the Engineer shall be borne by the Contractor.

**602.03.2--Protection of Materials.** Steel reinforcement shall be protected in accordance with Subsection 805.03.1.

**602.03.3--Bending.** Bending shall be in accordance with Subsection 805.03.2.

**602.03.4--Placing and Fastening.** The steel reinforcement shall be accurately

placed in the positions shown on the plans and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections, except where spacing is less than one foot in each direction alternate intersections may be tied.

All reinforcing steel shall be securely spaced from the forms and between layers by means of approved precast mortar blocks of minimum size for adequacy, or metal spacers or devices.

Where possible, all spacer devices shall be arranged so that they cannot be detected in the completed structure. Metal devices which are in contact with the exterior surface of the concrete shall be one of the types specified in Subsection 711.02.7. Gravel, pieces of broken stone or brick, metal pipe, and wooden blocks shall not be used for spacers or chairs.

Reinforcement shall be accurately and securely placed to the dimensions shown on the plans, within a tolerance of one-half inch, then inspected and approved by the Engineer prior to the placing of concrete. Concrete placed in violation of this provision may be rejected and its removal required.

Substitution of different size bars will be permitted only with specific authorization by the Engineer. If steel is substituted, it shall have a cross sectional area equivalent to or greater than the design area.

**602.03.4.1--Splicing.** Except where shown on the plans, splicing of bars will not be permitted without the written approval of the Engineer. Splices, when permitted, shall be staggered as far apart as possible.

Unless otherwise shown on the plans, spliced bars shall be lapped 20 diameters. In lapped splices, the bars shall be placed in contact and wired together in a manner that will maintain the minimum clear distance specified between bars and to the surface of the concrete.

Welding of reinforcing steel will be permitted only if detailed on the plans or if authorized by the Engineer in writing. If welded, it shall conform to AWS Recommended Practices for Welding Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction.

**602.03.4.2--Lapping of Mesh and Bar Mats.** Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall be at least one mesh in width.

**602.04--Method of Measurement.** Reinforcing steel will be measured in pounds based on the computed weight of the reinforcement shown on the plans or authorized. In cases where a structure is measured and paid for by the unit, complete in place, no measurement of reinforcing steel will be made.

The weight of plain or deformed bars and bar mats will be computed from the weights shown in the table of areas and weights in Subsection 711.02.1.

The weight for payment of steel fabric reinforcement will be computed from the theoretical weight of plain wire. If the weight per unit of area of the fabric is shown on the plans, that weight will be used for measurement.

The weight for payment of structural steel reinforcement will be the theoretical weight of the material used.

No allowance will be made for clips, wire, separators, wire chairs, and other material used in fastening the reinforcing in place. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the quantity specified will be measured.

When splice laps, other than those shown on the plans, are made for the convenience of the Contractor, the extra steel will not be included in the measurement.

**602.05--Basis of Payment.** Reinforcing steel will be paid for at the contract unit price per pound which shall be full compensation for completing the work.

Payment will be made under:

602-A: Reinforcing Steel - per pound

## SECTION 603 - CULVERTS AND STORM DRAINS

**603.01--Description.** This work consists of the construction or reconstruction of pipe culverts, precast box culverts, cattlepasses, storm drains, sewers, downspouts, special sections and headwalls, hereinafter referred to as "conduit," in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans or established. It shall also consist of furnishing all materials, except those specified to be furnished by the State, and joining the work to other conduit, catch basins, manholes, inlets, etc., as may be required to complete the work as designated.

This work shall also consist of constructing conduits for the encasement of underground utilities or for other use by the method of jacking or boring in accordance with these specifications and in reasonably close conformity with the lines and grades specified on the plans or established.

When alternate pipe is shown in the contract, the Contractor may select an alternate pipe from the alternate pipe group (type) shown in the plans or contract documents. The type of pipe used for alternate pipe shall meet the material

requirements of Subsection 603.02 for the type of pipe selected.

**603.02--Materials.** Conduit shall conform to the design and dimensions shown on the plans, and materials shall meet the requirements specified in the following sections or subsections:

Bituminous coated corrugated aluminum pipe and pipe arches..... 709.11

Bituminous coated corrugated metal pipe and pipe arches ..... 709.03

Bituminous coated paved invert corrugated aluminum pipe and  
pipe arches ..... 709.12

Bituminous coated paved invert corrugated metal pipe and pipe arches ..... 709.04

Bituminous plastic sealer for joints..... 707.05

Cast iron pipe ..... 709.01

Concrete arch pipe end sections..... 708.04

Concrete for headwalls..... 601

Concrete pipe cattlepasses ..... 708.03

Corrugated aluminum pipe and pipe arches..... 709.09

Corrugated metal pipe and pipe arches ..... 709.02

Corrugated poly vinyl chloride (PVC) pipe..... 708.17

Corrugated polyethylene pipe,..... 708.17

Elbows and branch connections for concrete pipe..... 708.23

Flexible plastic gaskets for joints..... 707.06

Joint mortar ..... 707.03

Joints for sanitary sewers ..... 603.03.4

Metal end sections, elbows, and branch connections..... 709.18

Non-reinforced concrete pipe..... 708.02.4

Polymer coated corrugated metal pipe and pipe arches ..... 709.05

Precast box culverts ..... 708.22

Reinforced concrete arch pipe..... 708.14

Reinforced concrete elliptical pipe ..... 708.15

Reinforced concrete end sections..... 708.04

Reinforced concrete pipe ..... 708.02.5

Reinforcing steel ..... 602

Rubber type gaskets ..... 707.04

Steel pipe..... 709.19

When material requirements provide for modifications of design, acceptable modified designs will be shown on the plans.

**603.03--Construction Requirements.**

**603.03.1--Excavation.** Except for conduit to be installed by jacking and boring, trenches shall be excavated in accordance with the requirements of Section 206 to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill material under and around the conduit. Where feasible, trench walls shall be vertical.



The completed trench bottom shall be firm for its full length and width. Where required, in the case of cross drains, the trench shall have the camber specified.

Where conduit is to be placed in embankment, the excavation shall be made after the embankment has been completed to the specified height above the flow line of the conduit. In all cases the height above flow line shall be at least one foot.

In the case of pipe to be jacked or bored, only the trench excavation and bedding as set out in Subsection 603.03.9 shall be performed.

**603.03.2--Bedding.** Except for conduit placed in a vertical position or jacked or bored, the conduit bedding shall conform to one of the classes specified. When no bedding class is specified the requirements for Class C bedding or Class C modified bedding, as applicable shall apply.

CLASS A bedding consists of a continuous concrete cradle conforming to plan details, and constructed on an approved foundation.

CLASS B bedding consists of bedding the conduit to a depth of at least 30 percent of the vertical outside dimension of the conduit. The thickness of bedding material beneath the pipe shall be at least four inches. The bedding material shall be sand or selected sandy soil, all of which passes a 3/8 inch sieve and not more than 10 percent of which passes a No. 200 sieve. The layer of bedding material shall be shaped to fit the conduit for at least 15 percent of its total height. Recesses in the trench bottom shall be shaped to accommodate the bell when bell and spigot type conduit is used.

CLASS C bedding consists of bedding the conduit to a depth of at least 10 percent of its total height. The bed shall be shaped to fit the conduit and shall have recesses shaped to receive the bell if bell and spigot type pipe is used.

CLASS C MODIFIED bedding consists of bedding corrugated conduit to a depth of at least 10 percent of its total height. A bedding blanket of approved silty loam, sandy loam, concrete sand, or other approved sand or sandy soil shall be roughly shaped to fit the bottom of the pipe. Minimum thickness before placing pipe shall be as follows:

- 1 inch for 1/2 inch deep corrugations
- 2 inches for 1 inch deep corrugations
- 3 inches for 2 inches or 2 1/2 inches corrugations

For structural plate pipe the length of bedding arc need not exceed the width of the bottom plate.

Bedding for precast concrete box culverts shall consist of at least two inches of

Class 9, Group C, or better, granular material placed between graded forms set at least one foot outside each outside wall of the box culvert. The granular material shall be shaped to fit the bottom of the precast box culvert sections by screeding off the graded forms. After placement of the precast box culvert sections on the graded bedding, the forms may be removed and reused.

**603.03.3--Laying Conduit.** The conduit laying shall begin at the staked location of the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream. Flexible conduits shall be placed with longitudinal laps or seams at the sides. Transverse joints for all types of coated flexible conduits shall maintain pipe alignment during construction and prevent infiltration of backfill material during the life of the structure.

Paved or partially lined conduit shall be laid so that the longitudinal center line of the paved segment coincides with the flow line. Elliptical and elliptically reinforced conduits shall be placed with the major axis within five degrees of a horizontal plane through the longitudinal axis of the conduit.

Construction requirements for end sections shall conform to the requirements for placing the pipe to which they are joined.

At the Contractor's option, subject to the written approval of the Engineer, concrete headwalls conforming to the Department's Standard Drawings may be substituted for premanufactured end sections without change in compensation.

**603.03.4--Joining Conduit.**

**603.03.4.1--Storm Drainage.** Rigid conduits may be either bell and spigot or tongue and groove design unless one type is specified. The method of joining conduit sections shall be such that the ends are fully entered, and the inner surfaces are reasonably flush and even. Unless otherwise specified, joints shall be sealed with rubber type gaskets, bituminous plastic sealer, or flexible plastic gaskets.

Joints for precast concrete box culverts shall be made with bituminous plastic sealer.

Rubber type gaskets shall be installed so as to form a flexible watertight seal.

For joints to be sealed with bituminous plastic, the joining ends shall be wiped clean and dry. The plastic compound shall be applied cold to the entire surface of tongues and grooves, the entire surface of bells and spigots, and the entire area of metal pipes to be covered by connecting bands. Sections of concrete pipe shall be forced together, and sections of metal pipe banded together, with excess

compound extruding both inside and outside the pipe. Excess compound shall be removed from interior surfaces, and the exterior shall be finished reasonably flush. After pipe has been joined with bituminous plastic compound, suitable kraft or other approved paper shall be placed over the outside joints to avoid mixing of soil with the compound.

For joints to be sealed with flexible plastic gasket material, the pipe shall be installed in a dry trench. Joints shall be made in such a manner that a slight internal extrusion of the plastic gasket will occur for the full circumference when the sections of pipe are forced together. Installation shall be in accordance with these specifications and the manufacturer's instructions. Plastic gasket material shall be applied only to surfaces which are dry. A primer of the type recommended by the manufacturer of the plastic gasket shall be applied to the tongue and groove and to the end surfaces, and the surface to be primed shall be clean and dry when the primer is applied. During cold weather the joint surfaces and the gasket shall be lightly heated, without damage to the pipe or joint material, immediately prior to forcing the sections of pipe together. During hot weather the Contractor shall place kraft or other approved paper over the joints to avoid mixing soil with the plastic gasket material.

For joints constructed of either bituminous plastic sealer or flexible plastic material, special care shall be taken to provide an equal uniform joint between pipe sections and to prevent one section from supporting the other. Backfilling operations may follow immediately.

Flexible conduits shall be firmly joined by coupling bands. The ends of flexible conduits fabricated with helical corrugations shall be adapted by reforming and/or modification for circumferential corrugated coupling bands. The width and thickness of corrugated bands for both circumferential and helical corrugated flexible conduits shall be in accordance with AASHTO Designation: M 36 except that the bands shall be no less than 10½ inches in width.

In lieu of the preceding requirements and in addition to being supplied or recommended by the pipe manufacturer, coupling bands for joining corrugated polyethylene pipe shall be in accordance with AASHTO Designation: M 294 and shall meet or exceed the soil-tightness requirements of the AASHTO Standard Specifications for Highway Bridges, Section 26, paragraph 26.4.2.4 (e).

Corrugated polyethylene pipe may also be furnished with bell & spigot type joints with O-ring rubber gasket meeting ASTM Designation: F 477 placed on the spigot end. At least two (2) corrugations of the spigot end must insert into the bell end.

Joints and fittings for poly vinyl chloride (PVC) pipe shall meet the requirements of ASTM Designation: F 949.

**603.03.4.2--Pipe With Gaskets.** Unless otherwise specified, joints for pipe requiring gaskets shall conform to the following:

- (a) Pipes requiring gaskets shall be constructed to accommodate the gasket in accordance with the recommendations of the manufacturer of the gasket. Rubber gaskets shall comply with Subsection 707.04, and flexible plastic gaskets shall comply with Subsection 707.06.
- (b) In municipalities and other local governments having codes and specifications for joining sanitary sewer conduit, the local codes and specifications shall be applicable.
- (c) Depending upon the type of pipe specified and the joint to be used, the Contractor shall perform the joining in accordance with the recommendations of the manufacturer of the joint material to the extent that the line will be water proofed both from infiltration and exfiltration insofar as is practicable. Evidence of leakage shall be corrected immediately.
- (d) Evidence of leakage or suspected leakage may be cause for requiring the Contractor to perform testing to determine the leakage present. In the case of sanitary sewer lines, leakage exceeding the tolerance permitted under the local governing code, or in the absence of such code the tolerances permitted by the Mississippi Department of Environmental Quality, Office of Pollution Control, will not be allowed.

Leakage in excess of the tolerances permitted shall be corrected by reworking the line as necessary. Retesting may be required if deemed by the Engineer to be indicated. All testing shall be at no additional cost to the Department.

**603.03.5--Relaid Pipe.** These construction specifications shall equally apply to relaid conduits. In addition, conduit salvaged for relaying shall be cleaned of all foreign material prior to reinstallation. All pipe damaged through carelessness or negligence on the part of the Contractor shall be replaced by new pipe or approved pipe at no additional cost to the Department.

Pipe and end sections designated for removal and relaying shall be removed in accordance with the provisions of Subsection 202.03.4.

**603.03.6--Field Strutting.** Where required by the plans, the vertical diameter of round flexible pipe shall be uniformly increased five percent by means of jacks applied after the entire line of pipe has been installed on the bedding but before backfilling. The vertical elongation shall be uniformly maintained by means of sufficient sills and struts or by sufficient horizontal ties as specified. Only horizontal ties shall be used for paved invert pipe.

Ties and struts shall be removed after the embankment is completed and compacted.

**603.03.7--Backfilling.** Conduit shall be inspected before backfill is placed. Conduit found to be out of alignment, unduly settled, or damaged shall be taken up and relaid or replaced. After approval of conduit, it shall be backfilled with specified material in accordance with Subsection 203.03.8.6.

**603.03.8--Imperfect Trench.** Under this method, the embankment shall be completed to a height above the conduit equal to the vertical outside diameter of the conduit plus one foot. A trench equal in width to the outside horizontal diameter of the conduit shall then be excavated to within one foot of the top of the conduit with the trench walls being as nearly vertical as possible. This trench shall be loosely filled with highly compactable soil. Straw, hay, corn stalks, leaves, brush, or sawdust may be used to fill the lower one-fourth to one-third of the trench. Construction of the remainder of the embankment shall then proceed in a normal manner.

**603.03.9--Pipes and Encasements Jacked or Bored.** No pipe shall be placed by jacking or boring unless so designated in the contract.

When jacking or boring is designated, the area of placement shall be carefully investigated so as not to interfere with existing underground utilities. Care shall also be taken to keep the disturbed area of construction to a minimum.

The line and grade and the limits, if any, of placement to be made by conventional open trench methods for each line of pipe will be established as provided in Subsection 105.08. Unless otherwise shown on the plans, sections of steel pipe shall be joined by welding for the full circumference of the pipe to form a continuous, rigid, watertight structure of the required length. Welding shall be performed in accordance with Subsection 810.03.5.

**603.03.9.1--Jacking.** The designated strength of the pipe to be jacked is determined for the final loading under the embankment. Additional reinforcement or strength of pipe required to withstand jacking pressure shall be the responsibility of the Contractor. Extra strength pipe furnished by the Contractor shall be at no additional cost to the Department.

Pipe larger than a 3½-inch ID shall not be pushed or jacked without boring or otherwise removing the soil as the pipe is advanced.

When required, suitable pits or trenches shall be excavated for the jacking operation and for placing the end joints of pipe. Where necessary, they shall be securely sheeted and braced to prevent caving.

Where pipe is required to be installed under railroads, highways, streets or other

facilities by jacking or boring methods, construction shall be done in a manner that will not interfere with the operation of the facility or weaken the roadbed or structure.

Jacks for forcing the pipe through the roadbed shall have a jacking head constructed in such a manner as to apply uniform pressure around the ring of the pipe. The pipe to be jacked shall be set on guides braced together to properly support the section of the pipe and direct it to the proper line and grade. In general, roadbed material shall be excavated just ahead of the pipe, the excavated material removed through the pipe, and the pipe then forced through the roadbed into the excavated space.

When requested, the Contractor shall furnish for the Engineer's approval a plan showing proposed method of handling. The plan shall include the design for the jacking head, and show the jacking support or back stop, arrangement and position of jacks, pipe guides, etc. complete in assembled position. The approval of this plan by the Engineer will not relieve the Contractor from the responsibility of obtaining the specified results.

The diameter of the excavation shall conform to the outside circumference of the pipe as closely as practicable. Voids which develop during the installation operation and which are determined by the Engineer to be detrimental to the work shall be pressure grouted with an approved mix.

The distance that the excavation extends beyond the end of the pipe will depend upon the character of the excavated material, but shall not exceed two feet in any case. This distance shall be decreased on instructions from the Engineer if the character of the material being excavated makes it desirable.

The pipe shall be jacked from the low or downstream end. Variation in the final position of the pipe from the line and grade established will be permitted only to the extent of two percent in lateral alignment and one percent in vertical grade, provided that the final grade of flow line is in the direction designated.

The Contractor may use a cutting edge around the head end which extends a short distance beyond the pipe end and has inside angles or lugs to keep the cutting edge from slipping back into the pipe.

When jacking of pipe is once begun, the operation shall be carried on without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

All pipe damaged in jacking operations shall be removed and replaced by the Contractor at no additional cost to the State.

Pits or trenches excavated to facilitate jacking operations shall be backfilled

immediately after the jacking has been completed.

**603.03.9.2--Boring.** The boring shall proceed from a pit provided for the boring equipment and workmen. Excavation for pits and installation of shoring shall be as outlined under jacking. The location of the pit shall meet the approval of the Engineer. The holes are to be bored mechanically. The boring shall be done using a pilot hole. By this method an approximate two-inch pilot hole shall be bored the entire length of the crossing and shall be checked for line and grade on the opposite end of the bore from the work pit. This pilot hole, when approved, shall serve as the centerline of the larger diameter hole to be bored. Excavated material shall be placed near the top of the working pit and disposed of as required. The use of water or other fluids in connection with the boring operation will be permitted only to the extent to lubricate cuttings as provided herein. Jetting will not be permitted.

In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10 percent of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and installation of the pipe immediately thereafter.

Allowable variation from line and grade shall be as specified under jacking. Precise measures are to be taken to prevent overcutting. Overcutting in excess of one-half inch shall be remedied by pressure grouting.

**603.03.9.3--Grouting, Backfilling, and Cleanup.** After the jacked conduit is in place, all joints in concrete pipe shall be cleaned carefully and pointed from the inside to afford a smooth continuous interior surface.

Extension of the line beyond that required to be jacked or bored shall be by conventional methods as set out in this section.

As soon after jacking as possible, the interstices around the outside of the pipe shall be filled by pressure grouting. The grout mixture shall consist of fine sand or silt, Type I cement of not less than 15 percent by volume, and water. The grout shall be placed through holes bored at such intervals that the grout can be determined as rising in an adjacent hole at least six inches above the top of the pipe. The water content of the grout shall be the minimum necessary to provide proper placement. Grouting shall be performed by qualified personnel with equipment especially designed for the purpose.

At the end of each day's grouting operation, or at the completion of the grouting operation for each line of pipe, whichever occurs first, the conduit shall be carefully inspected on the inside and all grout which has penetrated the pipe shall be removed and the inside surface wiped clean. Other waste grout which will impair the work shall be removed and disposed of.

After successive operations are completed, all sheeting, shoring, etc. shall be removed, excavations backfilled to the surface of the existing ground or as directed., the backfill compacted in accordance with the specifications, and all surplus material disposed of to the satisfaction of the Engineer.

**603.04--Method of Measurement.** The lengths of pipe and precast box culverts will be measured by the linear foot by multiplying the number of commercial lengths installed by the nominal length per section; except, portions of commercial lengths extending more than four feet beyond the ends of conduit actually required or at the face of structures will not be measured for payment.

Unless otherwise indicated on the plans, sections of lines of conduits placed by conventional methods will not be measured as pipe jacked or bored.

End sections, headwalls, elbows, branch connections, and other appurtenances for which pay items are listed will be measured by the number of units of the kind and size specified.

Pipe removed and relaid will be measured by the linear foot. End sections removed and relaid will be measured by the unit.

Excavation for conventionally installed conduits will be measured and paid for as set out in Section 206. Excavation for conduits placed by jacking or boring will not be measured for separate payment.

Excavation for precast box culverts will be measured in cubic yards as set out in Section 206 for cast-in-place box culverts of comparable sizes.

**603.05--Basis of Payment.** Accepted quantities of pipe and precast box culverts will be paid for at the contract unit price per linear foot.

End sections, headwalls, elbows, branch connections, and other appurtenances for which pay items are listed in the contract will be paid for at the contract unit price per each.

Pipe removed and relaid will be paid for at the contract unit price per linear foot. End sections removed and relaid will be paid for at the contract unit price per each.

The prices thus paid shall be full compensation for completing the work. Materials or work for which a pay item is not included and are necessary to complete the work under this section shall be furnished or performed and shall be considered incidental to the completed construction.

Payment will be made under:



### FERROUS METAL CONDUIT

603-A: \_\_\_\_ " Steel Pipe, Wall Thickness \_\_\_\_ - per linear foot

603-B: \_\_\_\_ " Cast Iron Pipe, Class \_\_\_\_, Description - per linear foot

### ALTERNATE CONDUIT

603-ALT: \_\_\_\_ " Type \_\_\_\_ Alternate Pipe - per linear foot

### CONCRETE CONDUIT

603-CA: \_\_\_\_ " Reinforced Concrete Pipe, Class \_\_\_\_ - per linear foot

603-CB: \_\_\_\_ " Reinforced Concrete End Section - per each

603-CC: \_\_\_\_ " Non-Reinforced Concrete Pipe, Class \_\_\_\_ - per linear foot

603-CD: 48" x 72" Concrete Pipe Cattlepass - per linear foot

603-CE: \_\_\_\_ " x \_\_\_\_ " Concrete Arch Pipe, Class \_\_\_\_ - per linear foot

603-CF: \_\_\_\_ " x \_\_\_\_ " Concrete Arch Pipe End Section - per each

For conduit required to be jacked or bored, the appropriate pay item listed above will contain the term "Jacked" or "Bored", as applicable.

For conduit required to have rubber type or flexible type gasket, the appropriate pay item listed above will contain the term "Rubber Type Gasket" or "Flexible Type Gasket", as applicable.

### CORRUGATED FERROUS METAL CONDUIT

603-MA: \_\_\_\_ " \* Coated Corrugated Metal Pipe, \_\_\_\_ Gage,  
\_\_\_\_ Corrugation - per linear foot

603-MB: \_\_\_\_ " \* Coated Corrugated Metal End Section,  
\_\_\_\_ Gage - per each

603-MC: \_\_\_\_ " x \_\_\_\_ " \* Coated Corrugated Metal Arch Pipe,  
\_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-MD: \_\_\_\_ " x \_\_\_\_ " \* Coated Corrugated Metal End  
Section, \_\_\_\_ Gage - per each

603-ME: \_\_\_\_ " \* Coated Paved Invert Corrugated Metal  
Pipe, \_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-MF: \_\_\_\_ " \* Coated Paved Invert Corrugated Metal End  
Section, \_\_\_\_ Gage - per each

603-MG: \_\_\_\_ " x \_\_\_\_ " \* Coated Paved Invert Corrugated Metal  
Arch Pipe, \_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-MH: \_\_\_\_ " x \_\_\_\_ " \* Coated Paved Invert Corrugated Metal  
End Section, \_\_\_\_ Gage - per each

\* Type Coating to be shown as either Zinc, Aluminum, Polymeric or Bituminous.

NOTE: The gage of pipe specified for various coating types will vary according to the Department's design policy.

### **CORRUGATED NON-FERROUS METAL CONDUIT**

603-NA: \_\_\_\_ " Corrugated Aluminum Pipe, \_\_\_\_ Gage,  
\_\_\_\_ Corrugation - per linear foot

603-NB: \_\_\_\_ " Corrugated Aluminum End Section, \_\_\_\_ Gage - per each

603-NC: \_\_\_\_ " x \_\_\_\_ " Corrugated Aluminum Arch Pipe,  
\_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-ND: \_\_\_\_ " x \_\_\_\_ " Corrugated Aluminum End Section,  
\_\_\_\_ Gage - per each

603-NE: \_\_\_\_ " Bituminous Coated Corrugated Aluminum Pipe,  
\_\_\_\_ Gage - per linear foot

603-NF: \_\_\_\_ " Bituminous Coated Corrugated Aluminum End  
Section, \_\_\_\_ Gage - per each

603-NG: \_\_\_\_ " x \_\_\_\_ " Bituminous Coated Corrugated Aluminum  
Arch Pipe, \_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-NH: \_\_\_\_ " x \_\_\_\_ " Bituminous Coated Corrugated Aluminum  
End Section, \_\_\_\_ Gage - per each

603-NI: \_\_\_\_ " Bituminous Coated Paved Invert Corrugated  
Aluminum Pipe, \_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-NJ: \_\_\_\_ " Bituminous Coated Paved Invert Corrugated  
Aluminum End Section, \_\_\_\_ Gage - per each

603-NK: \_\_\_\_" x \_\_\_\_" Bituminous Coated Paved Invert Corrugated  
Aluminum Arch Pipe, \_\_\_\_ Gage, \_\_\_\_ Corrugation - per linear foot

603-NL: \_\_\_\_" x \_\_\_\_" Bituminous Coated Paved Invert Corrugated  
Aluminum End Section, \_\_\_\_ Gage - per each

### **CORRUGATED POLYETHYLENE CONDUIT**

603-PE: \_\_\_\_" Corrugated Polyethylene Pipe - per linear foot

### **CORRUGATED POLY VINYL CHLORIDE CONDUIT**

603-PVC: \_\_\_\_" Corrugated Poly Vinyl Chloride Pipe - per linear foot

### **PRECAST BOX CULVERTS**

603-PA: \_\_\_\_' x \_\_\_\_' Precast Concrete Box Culvert - per linear foot

603-PB: \_\_\_\_' x \_\_\_\_' Precast Concrete Box Culvert End Section - per each

### **RELAID PIPE**

603-RA: \_\_\_\_" Pipe Removed and Relaid - per linear foot

603-RB: \_\_\_\_" End Section Removed and Relaid - per each

### **SPECIALS AND CONCRETE HEADWALLS**

603-SA: Size & Angle Elbow, Materials per Pay Item No. \_\_\_\_ - per each

603-SB: Size Branch Connection Type & Description - per each

603-SC: Size & Type Headwall, Per Plans - per each

**SECTION 604 - MANHOLES, INLETS AND CATCH BASINS**

**604.01--Description.** This work consists of the construction of manholes, inlets, and catch basins in accordance with these specifications and in reasonably close conformity with the details, lines, grades, and dimensions shown on the plans or established by the Engineer.

Precast sectional manholes shall consist of furnishing and assembling precast sections for manholes, together with necessary fittings, bases, and connections, all constructed in accordance with these specifications and in reasonably close conformity with the details, lines, grades and dimensions shown on the plans, or established.

**604.02--Materials.** The materials used in this construction shall meet the requirements specified in the following Section or Subsections:

Masonry Brick, Grade SM .....	706.01
Mortar .....	714.11
Concrete .....	601
Reinforcing Steel .....	711.00 and 711.01
Gray Iron Castings .....	716.04
Bar Gratings .....	716.14

All bars, anchors, frames, hangers, etc. for castings and plates shall be approved prior to installation.

Inlet and outlet pipes shall be of the type, class and size indicated on the plans and shall conform to the requirements as set out in Section 603 for the particular type, class, and size of pipe specified.

Precast units will be considered for use under the provisions of Subsection 601.02.3. Precast (sectional) manholes shall conform to the requirements of AASHTO Designation: M 199.

**604.03--Construction Requirements.**

**604.03.1--Brick Masonry.** Brick masonry shall be constructed in conformity with the details shown on the plans and in accordance with the provisions of Section 611.

Where irons or other fittings enter the brick work, they shall be placed as the work is laid up, thoroughly bonded, accurately spaced, and lined. Upon completion of the masonry and setting of castings and fittings, the inside and outside surfaces of the masonry shall be neatly plastered with mortar 1/2 inch thick. Plastering shall have a uniform, smooth finish and shall be neatly pointed to all fittings.

**604.03.2--Concrete Masonry.** Unless otherwise specified, concrete masonry shall be constructed of Class "B" concrete in accordance with the requirements of Section 601.

**604.03.3--Reinforcement.** Reinforcement shall be placed as indicated on the plans or as directed and in accordance with the provisions of Section 602.

**604.03.4--Optional Construction.** When plan standards indicate portions of the structure may be constructed of either brick masonry or concrete, the Contractor may use either concrete or brick masonry for these portions, provided the plan dimensions for wall thickness, etc. are maintained. In either case the masonry, whether concrete or brick, will be measured for payment as stipulated in Subsection 604.04.

**604.03.5--Inlet and Outlet Pipes.** Unless otherwise directed, inlet and outlet pipes shall extend through the walls of manholes and catch basins for a sufficient distance beyond the outside surface to allow for connections and shall be cut flush with the wall on the inside surface and neatly pointed.

The concrete, or brick and mortar, shall be constructed around the pipes so as to prevent leakage and to form a neat connection.

**604.03.6--Castings, Gratings, and Fittings.** All castings and gratings shall be carefully handled. Injurious cracks, chips, surface mars, etc. which render them unsuitable for use or unsightly after being placed will be cause for rejection.

The castings, gratings, and fittings shall be placed as indicated on the plans or as directed to line and grade and in such a manner that subsequent adjustments will not be necessary.

When castings or gratings are to be set in concrete or cement mortar, all anchors or bolts shall be in the correct place and position before the concrete or mortar is placed, and they shall not be disturbed while the concrete or mortar is hardening.

Castings and gratings placed on previously constructed masonry shall be set in mortar beds or anchored to the masonry as shown on the plans or directed. The bearing surface of the original masonry shall present an even surface and conform to line and grade so that the entire face or back of the casting will come in contact with the masonry.

Castings and gratings shall be set firm and snug so that they will not rattle, shake, or move unnecessarily.

**604.03.7--Precast Manholes.** As trenches are opened for the pipe conduit, truly leveled bases shall be prepared at each manhole site. The bases may be cast-in-place or may consist of precast base units. In either case, the seated base shall be

truly horizontal. Inverts shall be smooth and accurately shaped to a semi-circular bottom conforming to the inside of the adjacent conduit, and extend upward at least half of the diameter of the conduit, or as shown on the plans. Joints shall be sealed in accordance with Section 603.

Steps in the manhole may be of cast-iron, aluminum, wrought iron, plastic or other material approved by the Engineer. All steps shall be built into the walls of precast sections in straight alignment to form a continuous ladder with a maximum distance of 16 inches between steps.

Each precast section shall have not more than two holes for handling. The holes shall be plugged with mortar after installation.

Concrete covers may be precast, or cast at the site. The covers shall be cast accurately to the dimensions and design indicated on the plans.

**604.03.8--Excavation and Backfill.** Excavation shall be performed as required for proper construction. Backfill shall be performed in accordance with the provisions of Subsection 203.03.8.6.

**604.03.9--Cleaning Up.** Upon completion, all structures shall be thoroughly cleaned of accumulations of silt, debris, and foreign matter. All surplus material shall be removed, and the site and the structure shall be maintained in a clean and neat condition until release of maintenance.

**604.04--Method of Measurement.** When either concrete masonry or brick masonry is permitted, and when concrete is specified, measurement will be by the cubic yard in accordance with 601.04 for Structural Concrete - Minor Structures.

Precast manholes will be measured per linear foot of depth from the flowline of the manhole to the top of the cover, or as indicated on the plans.

Reinforcing steel will be measured per pound in accordance with Subsection 602.04.

When brick masonry only is specified, measurement will be by the cubic yard or per thousand (M) brick in accordance with Subsection 611.04.

Excavation will not be measured for payment as a separate item. The cost of excavation shall be included in the unit price for concrete or brick masonry.

Castings, gratings and metallic manhole covers will be computed in pounds from the dimensions shown on the plans and based on the unit weights of metals set out in Section 810.

Fittings will not be measured for separate payment. Their cost shall be included in the price for concrete or brick masonry.

**604.05--Basis of Payment.** Structural concrete, reinforcing steel, and brick masonry will be paid for at the respective contract unit price in accordance with Subsections 601.05, 602.05, or 611.05 as applicable.

Precast Manholes will be paid for at the contract bid price per linear foot of depth, which price shall be full compensation for all necessary excavation, sheeting, cribbing, shoring, bracing, well-pointing, furnishing and assembling all elements of the manhole including concrete bases & covers except metallic cover and frame, for all other items of work necessary and incident to the complete construction and for all equipment, labor, tools and incidentals necessary to complete the work.

Castings and gratings will be paid for at the contract unit price per pound for castings or gratings, complete in place. These prices shall be full compensation for completing the work.

Payment will be made under:

- 604-A: Castings - per pound
- 604-B: Gratings - per pound
- 604-C: Precast Manhole, \_\_\_\_" Diameter - per linear foot

**SECTION 605 - UNDERDRAINS**

**605.01--Description.** This work consists of furnishing all materials and constructing pipe underdrains in accordance with these specifications and in reasonably close conformity with the lines and grades indicated on the plans or established by the Engineer; furnishing materials and constructing filter beds as specified; and furnishing and installing plastic pipe edge drains and edge drain outlets, vents and miscellaneous appurtenances as shown on the drawings in the plans, and as specified herein. This work also includes the video inspection and reporting of edge drain system installation.

**605.02--Materials.**

**605.02.1--Drain Tile and Pipe.** Drain tile and pipe shall be of the classes and sizes indicated and shall meet the requirements of the following Subsections:

- Bituminous Coated Corrugated Aluminum Alloy Pipe for Underdrains .... 709.13
- Bituminous Coated Corrugated Metal Pipe for Underdrains ..... 709.07

Concrete Drain Tile ..... 708.06

Corrugated Aluminum Pipe for Underdrains ..... 709.10

Corrugated Metal Pipe for Underdrains ..... 709.06

Corrugated Polyethylene Drainage Tubing ..... 708.19

Geotextile ..... 714.13

Perforated Concrete Pipe ..... 708.05

Plastic Pipe for Underdrains ..... 708.18

Polymer Coated Corrugated Metal Pipe for Underdrains ..... 709.08

Porous Concrete Pipe ..... 708.07

Semi-circular Perforated Plastic Pipe for Underdrains ..... 708.20

**605.02.2--Material for Bedding and Covering.** Bedding and covering material shall conform to the requirements of Section 704. Unless otherwise specified, Type C shall be used.

**605.02.3--Appurtenances.** Appurtenances such as flush-out units, small animal guards, signs, etc. shall be as shown on the plans and shall be of new, good commercial quality materials approved by the Engineer.

**605.02.4--Edge Drain Pipe and Fittings.**

**605.02.4.1--General.** Pipe for edge drains and fittings shall be four-inch nominal size, and shall be either Schedule 40 or Schedule 80 polyvinyl chloride (PVC) plastic pipe conforming to the requirements of ASTM Designation: D 1785.

Fittings, except for "Y" fittings, shall be socket-type fittings conforming to the requirements of ASTM Designation: D 2467 for Schedule 80 pipe and ASTM Designation: D 2466 for Schedule 40 pipe.

The Contractor may elect to furnish one of the following perforated pipe in lieu of the pipe listed above. Regardless of the pipe used, it shall be four-inch nominal size.

- a) Pipe conforming to Subsection 708.18 of the Standard Specifications with SDR number ranging from 23.5 to 35 and having a minimum pipe stiffness value of 50 psi
- b) Corrugated polyethylene drainage tubing or corrugated high density polyethylene (HDPE) pipe conforming to the requirements of AASHTO Designation: M 252, Type SP with the stipulation that the minimum pipe stiffness value shall be 50 psi. The pipe and fittings shall be made of virgin polyethylene compounds which conform with the requirements of cell class 324420C as defined and described in ASTM Designation: D 3350, except that the carbon black content shall not exceed 5%. Compounds that have higher cell classifications in one or more



properties are acceptable provided product requirements are met.

Pipe used for the edge drain outlet/vents shall be either PVC or corrugated high density polyethylene (HDPE) pipe. PVC pipe shall meet the requirements of ASTM Designation: D 1785 as stated above, and HDPE pipe shall meet the requirements of AASHTO Designation: M 252 as stated above.

All "Y" fittings shall be smooth interior wall fittings fabricated from pipe conforming to the requirements of the edge drain outlet pipe. The fitting shall provide an unobstructed passageway through both legs of the "Y".

Edge drain outlet and vent covers shall consist of commercial quality 3 x 3 galvanized hardware cloth, 0.063-inch wire or equal. The outlet and vent covers shall be installed at the end of each outlet pipe and vent pipe.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification covering each shipment of pipe stating the amount furnished and that the pipe, fittings, couplings, etc. comply with the requirements of the specifications.

**605.02.4.2--Untreated Permeable Material.** The untreated permeable material used to backfill the edge drain pipe and outlet/vent trenches shall be Type 57 filter material and shall conform to the requirements of Subsection 703.03, Coarse Aggregate for Portland Cement Concrete, for Size 57 coarse aggregate. The type of aggregate may also be slag or granite. Mixing of different types of aggregate will not be permitted.

**605.02.4.3--Filter Fabric.** The filter geotextile used with edge drains and edge drain outlets shall be Type V geotextile meeting the requirements of Subsection 714.13.

**605.02.4.4--Miscellaneous.** Concrete for aprons shall be Class "C" concrete meeting the requirements of Subsection 804.02.10.

Mortar placed where edge drain outlets and vents connect to drainage pipes and existing drainage inlets shall conform to the provisions of Subsection 714.11.5, Masonry Mortar, except that the sand and cement shall be commercial quality.

## **605.03--Construction Requirements.**

### **605.03.1--Pipe Installation.**

**605.03.1.1--Preparation of Trench.** Trenches shall be excavated to the dimensions and grade shown on the plans or as directed. In the event the dimensions of the trench are not indicated on the plans, the trench shall be at least as wide as the outside diameter of the pipe plus eight inches on each side, and

shall be of sufficient depth to allow proper installation of the pipe and covering.

If bell and spigot pipe is used, recesses shall be cut to allow uniform bearing of the pipe on the bottom of the trench.

#### **605.03.1.2--Pipe Laying.**

**605.03.1.2.1--General.** Except where settlement occurs due to reasons beyond the control of the Contractor, the Contractor shall be responsible for the alignment and grade of pipe underdrains. Where settlement occurs due to improper excavation, bedding or backfill, negligence, or carelessness on the part of the Contractor, the pipe shall be taken up and properly relaid or replaced without extra compensation.

**605.03.1.2.2--Drain Tile.** Drain tile shall be firmly embedded on the bottom of the trench, conforming to line and grade, and with the ends approximately 1/4 inch apart. If, in the judgment of the Engineer, the soil is of a composition such that it will wash into the joints, the joints shall be wrapped with strips of tar paper approximately four inches wide. Bedding or cover material shall then be placed around the paper to prevent its displacement. No additional compensation will be allowed for this operation.

**605.03.1.2.3--Bell and Spigot Type.** Concrete pipe of the bell and spigot type shall be firmly embedded on the bottom of the trench, with the bell ends up grade, and shall have close fitting joints. No mortar will be required in the joints.

**605.03.1.2.4--Perforated Pipe.** Unless otherwise indicated on the plans, perforated pipe shall be laid with the perforated side down. Unless otherwise specified, perforated pipe shall be laid on a four-inch bed of approved filter material.

**605.03.1.2.5--Corrugated Metal Pipe.** Corrugated metal pipe shall be laid with the separate sections firmly joined together by connecting bands of an approved type.

**605.03.1.2.6--Laterals.** Laterals and other connections shall be made with suitable special sections.

**605.03.1.2.7--Dead Ends.** Dead ends of pipe underdrains shall be closed with a suitable plug of concrete placed over and around the end so as to hold the pipe securely in place.

**605.03.1.2.8--Underdrain Outlets.** When indicated on the plans non-perforated underdrain outlets shall be joined to the underdrains.

**605.03.1.3--Appurtenances.** Underdrain appurtenances such as flush-out units,

small animal guards, signs, etc. shall be constructed in accordance with the details shown on the plans and shall be of good quality workmanship.

**605.03.1.4--Pipe Covering.** After the pipe underdrain has been laid, it shall be covered immediately with the specified filter material to the dimensions shown on the plans. The remainder of the trench, if any, shall be filled with the specified material, placed in six-inch layers, and compacted to the specified density.

**605.03.2--Blind Drains.** Trenches for blind drains shall be excavated to the width and depth shown on the plans. The trench shall be filled with filter material to the depth required by the plans. The remaining upper portion of trench shall be filled with either granular or impervious material as specified. All filling material shall be thoroughly compacted, and if under the pavement structure the material shall be compacted to the density specified in the contract.

**605.03.3--Combination Storm Drain and Underdrain.** Where the plans indicate that a conduit is to serve as a combination storm drain and underdrain, the conduit shall in general be constructed in accordance with Section 603. Modifications of Section 603 to provide that the conduit also serve as an underdrain shall be performed under this section. Modifications shall be as shown on the plans.

The Contractor shall carefully grade and shape the compacted backfill for the lower portion of the pipe so that water entering the filter material will be adequately drained into the unsealed portion of the joints. In no case shall the surface of the compacted backfill be below the sealed portion of the joints. After the lower portion of the joint has been backfilled, compacted, and shaped as indicated above, filter material shall be placed for the full depth shown on the plans.

Each layer of filter material shall be compacted to the satisfaction of the Engineer.

Upon completion of the placement and compaction of the filter material, superimposed materials shall be placed immediately, or a temporary covering of approved material shall be placed and compacted in order to prevent unnecessary infiltration of loose material into the upper portion of the filter material. Should appreciable contamination occur because of failure to adequately protect the surface of the filter material, that portion of the work considered to be unsatisfactory shall be removed and replaced with satisfactory work at no additional cost to the Department.

If temporary materials used to protect the upper portion of the filter material do not meet the requirements for the superimposed course, the temporary materials shall be carefully removed to expose clean filter materials immediately prior to

placement of the required superimposed course.

**605.03.4--Filter Beds.** Excavation for filter beds shall be made to the elevation and dimensions indicated on the plans. The surface of the excavated area on which the filter bed is to be placed shall be smooth, firm, and well drained. Filter material of the types shown on the plans shall be placed, thoroughly compacted, and shaped to the dimensions indicated on the plans. Unless otherwise specified, compaction shall be to the satisfaction of the Engineer.

When impervious material or other materials are specified to be placed over the filter material, the compacted filter material shall be covered as soon as practicable with this material and compacted to the required design soil density in accordance with Section 203.

**605.03.5--Edge Drain Installation.** Edge drains, edge drain outlets, vents, untreated permeable material, and filter geotextile shall be installed in accordance with the details shown on the plans or in the contract documents, as specified herein and applicable Special Provisions. The vertical tolerance (height) for the trench shall be plus or minus one-half inch. The horizontal tolerance (width) shall be plus one inch.

Surfaces to receive filter fabric, immediately prior to placing, shall be free of loose or extraneous material and sharp objects that may damage the filter geotextile during installation.

The geotextile shall be stretched, aligned and placed in a wrinkle-free manner.

Adjacent rolls of the geotextile shall be overlapped from 12 to 18 inches. The preceding roll shall overlap the following roll in the direction the material is being spread.

Should the geotextile be damaged during placing, the torn or punctured section shall be either completely replaced or shall be repaired by placing a piece of geotextile that is large enough to cover the damaged area and to meet the overlap requirement.

Damage to the geotextile resulting from the Contractor's vehicles, equipment or operations shall be replaced or repaired by the Contractor at no additional cost to the State.

Pipe and fittings shall be joined by solvent cementing with commercial quality solvent cement and primer specifically manufactured for use with rigid PVC plastic pipe and fittings. The solvent cement and primer used shall be made by the same manufacturer. The color of the primer shall contrast with the color of the pipe and fittings. The solvent cement and primer shall be used in accordance with the manufacturer's printed instructions.

When corrugated polyethylene drainage tubing is used, joints shall be made with split couplings, corrugated to engage the pipe corrugations, and shall engage a minimum of four corrugations, two on each side of the pipe joint.

When poly vinyl chloride corrugated sewer pipe is used, joints shall be made in accordance with the pipe manufacturer's recommendations and ASTM Designation: F 949.

The backfill of the trench along the pavement edge, across the shoulder and outside the shoulder shall be as shown in the details of the drawings.

The Contractor may dispose of the trenched materials on the slopes provided all material passes a three-inch ring and blends into the existing or reconstructed roadway slopes. Otherwise, the material must be disposed of outside the right-of-way.

The edge drain and edge drain outlets and vents shall be clean at the time of installation and shall be free of obstructions after installation.

**605.03.6--Edge Drain Inspection.** The edge drain system shall be inspected by the Contractor after all roadway construction items are completed within a given section of roadway. A video record and written report for each line inspected shall be furnished to the Engineer. The line location (station number), distance traversed by the camera, and pipe deficiency shall be recorded on a standard VHS video tape and in a written report. As a minimum, fifty percent (50%) of the entire edge drain system shall be video inspected. Video inspection shall be performed in the presence of the Engineer or his/her representative.

Video equipment used for inspecting the edge drain system shall be capable of the following minimum requirements:

- (1) Providing color video inspection of pipelines for 4-inch inside diameter pipe in a wet, corrosive environment and negotiating a 90° bend in a smooth bore or corrugated pipe. The color camera must have a minimum 400-line horizontal resolution.
- (2) Video inspecting up to 300 linear feet of edge drain pipe, by pushing, pull cabling, jetting or tractoring the camera through the line and recording the condition on video tape.
- (3) Equipped with a video monitor capable of allowing live viewing of the video inspection.
- (4) Displaying and recording on the video tape, the date, line identification, footage and type of pipe deficiency.

- (5) Recording the distance traversed by the camera to within 0.5 feet, allowing for overlapping of distances if a reversal is required to permit full-length inspection.

A written report of the drain system inspection shall be completed on the MDOT Edge Drain and Edge Drain Outlet/Vent Inspection Form, or other form approved by the Engineer.

Any foreign materials that restricts the movement of the inspection equipment or impairs the quality of the video within the drain system shall be flushed from the system. Flushing of the drain system will be by water jetting or other methods approved by the Engineer. Costs associated with flushing the system will not be made under separate payment. The system shall be re-inspected after flushing in the same manner as the initial inspection as described above. Re-inspection of the system shall be at no additional cost to the State.

Any drain system pipe that can not be cleared from obstructions, damaged or does not conform to the lines and grades shown on the plans shall be replaced at no additional cost to the State.

**605.04--Method of Measurement.** Tile or pipe underdrains, including all special sections and connections, and blind drains will be measured from end to end by the linear foot along their center lines.

Appurtenances, specified as pay items, will be measured by the unit indicated. All necessary appurtenances not listed as pay items will not be measured for separate payment.

Excavation for pipe underdrains will be measured and paid for under the provisions of Section 206 for the widths shown on the plans. Excavation for blind drains and filter beds will be measured and paid for in accordance with the provisions of Section 203.

Measurement and payment for conduit required to be used as combination storm drain and underdrain will be made in accordance with Section 603, except for those features modified as provided in this section.

Measurement of filter materials used in the construction of underdrains, combination storm drains and underdrains, and filter beds will be made as follows:

- (a) In the case of underdrains and combination storm drains and underdrains, the measurement will be made complete-in-place and computed from plan dimensions. No deduction will be made for the volume occupied by pipe or portion of pipe for pipes eight inches and less in diameter. Deductions will be made for pipes larger than eight inches in diameter.

- (b) In the case of filter beds, the material of the required types will be measured by the cubic yard (LVM) or by the ton as indicated in the proposal, from which will be deducted all quantities determined by the Engineer to have been placed in excess of that necessary because of the failure of the Contractor to establish and maintain the grades, lines, slopes, and other dimensions in reasonably close conformity with those shown on the plans or established by the Engineer. In computing the volume of quantities to be deducted from LVM measurement, the Engineer will determine the excess by the best procedure deemed appropriate and convert the results to LVM as provided in Subsection 109.01.

When measurement by the ton is indicated on the plans and in the proposal, measurement will be based on the dry unit weight in accordance with Subsection 304.04.

Except when specifically indicated as a pay item, no measurement for payment will be made for filter material for blind drains.

When designated as a pay item in the contract, geotextile for subsurface drainage will be measured by the square yard based on plan dimensions.

Edge drains and edge drain outlets/vents, complete in place, will be measured by the linear foot along the line of the trench. On slopes the length to be paid for will be the slope length of the trench.

Edge drain inspection will be measured by the linear foot of edge drain and edge drain outlet/vent inspected. The length to be paid for will be the slope length of the trench.

The Class "C" Concrete for concrete edge drain aprons shall be measured by the cubic yard.

Wire mesh covers, pipe and pipe fittings, couplings, untreated permeable material, geotextile fabric, granular material, bituminous pavement mixture, trenching, disposal of trenched materials and other miscellaneous appurtenances used for edge drain installation will not be measured separately for payment.

**605.05--Basis of Payment.** Tile and pipe underdrains and blind drains will be paid for at the contract unit price per linear foot. Appurtenances listed as pay items will be paid for at the contract unit price for the units specified.

Filter material for underdrains and combination storm drains and underdrains will be paid for at the contract unit price per cubic yard (FM).

Filter material for filter beds will be paid for at the contract unit price per cubic yard (LVM) or ton.

Excavation for tile or pipe underdrains will be paid for in accordance with the provisions of Subsection 206.05. Excavation for blind drains will be paid for in accordance with the provisions of Subsection 203.05.

Geotextile for subsurface drainage will be paid for at the contract unit price per square yard.

Edge drain and edge drain outlets/vents will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in constructing edge drains and edge drain outlets/vents complete in place, including wire mesh covers, pipe and pipe fittings, couplings, untreated permeable material, geotextile fabric, granular material, bituminous pavement mixture, trenching, disposal of trenched materials and other miscellaneous appurtenances as shown on the plans and as specified herein.

Edge drain inspection, completed and accepted, will be paid for at the contract unit price per linear foot of edge drain and edge drain outlet/vent inspected, which price shall be full compensation for furnishing all labor, equipment, VHS tapes, tools and incidentals necessary to complete the work.

Class "C" concrete for edge drain aprons as shown on the plans and as specified herein shall be paid for under Pay Item No. 221-A, Portland Cement Concrete Paved Ditch.

The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

- 605-A: \_\_\_\_" Concrete Drain Tile for Underdrains, Class \_\_\_\_ - per linear foot
- 605-B: \_\_\_\_" Perforated Concrete Pipe for Underdrains,  
Class \_\_\_\_ - per linear foot
- 605-C: \_\_\_\_" Porous Concrete Pipe for Underdrains - per linear foot
- 605-D: \_\_\_\_" Perforated Corrugated Metal Pipe for Underdrains,  
Type \_\_\_\_ - per linear foot
- 605-E: \_\_\_\_" Non-perforated Corrugated Metal Pipe for  
Underdrains, Type \_\_\_\_ - per linear foot



## Section 605

## Section 605

605-F: ____" Bituminous Coated Perforated Corrugated Metal Pipe for Underdrains, Type____	- per linear foot
605-G: ____" Bituminous Coated Non-perforated Corrugated Metal Pipe for Underdrains, Type____	- per linear foot
605-H: Edge Drain	- per linear foot
605-I: Edge Drain Outlets/Vents	- per linear foot
605-J: Edge Drain & Edge Drain Outlet/Vent Inspection	- per linear foot
605-K: Blank	
605-L: Blank	
605-M: ____" Perforated Corrugated Aluminum Pipe for Underdrains, Type____	- per linear foot
605-N: ____" Non-perforated Corrugated Aluminum Pipe for Underdrains, Type ____	- per linear foot
605-O: ____" Perforated Sewer Pipe for Underdrains, SDR ____	- per linear foot
605-P: ____" Non-perforated Sewer Pipe for Underdrains, SDR ____	- per linear foot
605-Q: ____" Perforated Corrugated Polyethylene Drainage Tubing for Underdrains	- per linear foot
605-R: ____" Non-perforated Corrugated Polyethylene Drainage Tubing for Underdrains	- per linear foot
605-S: ____" Semi-circular Perforated Plastic Pipe for Underdrains	- per linear foot
605-T: ____" Perforated Pipe for Underdrains, Optional*	- per linear foot

\* Meeting the requirements for Pay Item Numbers 605-B, Standard Strength; 605-D, Type III; 605-K, Type SJ or TJ; 605-M, Type III; 605-O, SDR 35, 41 or 42; 605-Q, or 605-S.

605-U: \_\_\_\_" Non-perforated Pipe for Underdrains, Optional\*\* - per linear foot

\*\* Meeting the requirements for Pay Item Numbers 605-E, Type III; 605-L, Type SJ or TJ; 605-N, Type III; 605-P, SDR 35, 41 or 42; or 605-R.

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605-V: ____ " Blind Drains	- per linear foot
605-W: Filter Material for Combination Storm Drain and/or Underdrains, Type ____	- per cubic yard
605-X: Filter Material for Filter Beds, Type ____	- per cubic yard or ton
605-Y: Impervious Material, Type ____	- per cubic yard or ton
605-Z: Underdrain Appurtenances, <u>Description</u>	- per lump sum, each, etc.
605-AA: Geotextile for Subsurface Drainage, Type <u>***</u> , AOS <u>***</u>	- per square yard

\*\*\* When not designated, see Subsection 714.13.

**SECTION 606 - GUARD RAIL**

**606.01--Description.** This work consists of furnishing and erecting complete sections of guard rail in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans or established by the Engineer. This work shall also include the installation of reflectors on guard rail posts and the installation of guard posts.

When the work requires the removal and replacement of guardrail on a facility opened to traffic, the materials necessary for replacement will be on hand before removal begins. The Contractor shall not begin work on any section of guardrail until preparations have been made to complete the installation of the section, including posts, rail, anchors, and hardware as a continuous operation. Once work has been initiated on a section, the work shall be prosecuted to its completion unless inclement weather or other conditions beyond the control of the Contractor interfere with the work. Uncompleted guardrail or special end sections shall not be left exposed to the travelling public without the approval of the Engineer. If approval is granted, the uncompleted section must satisfactorily be marked with drums, barricades, or other devices, as directed by the Engineer, at no additional cost to the Department. In no case will uncompleted guardrail or special end sections be allowed to remain over a weekend or holiday period.

**606.02--Materials.** Unless otherwise specified, all materials shall conform to the requirements shown on the plans and set forth in Section 712. Reflectors shall be of the type, size, and color designated on the plans and shall conform to the requirements of Subsections 721.07, or 721.08, as applicable.

When not designated, guard rail posts, meeting the requirements of Subsection 712.06, may be wood or steel but shall be of the same type for the entire project.

Posts for bridge end sections shall be of the same type as the guard rail line posts. Posts for cable anchorage sections may be wood or steel but shall be of the same type for the entire project.

Terminal end sections, installed as per manufacturer's recommendations, shall be National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 3 (TL-3) approved.

The Contractor shall furnish the Project Engineer two (2) copies of the manufacturer's installation instructions prior to beginning guard rail operations.

### **606.03--Construction Requirements.**

**606.03.1--Erection of Guard Posts.** Generally, guard post will be constructed of timber post. However, on some occasion guard post may be constructed of steel with special requirements detailed on special design sheets in the plans. The posts shall be set plumb and firm to the depth indicated and accurately lined, spaced, and graded. After the posts are in place, the holes shall be backfilled with suitable material which shall be thoroughly compacted in approximate six inch layers by tamping. Posts shall not be sawed or cut after treatment. If set posts are found to be in improper position with reference to alignment or grade, they shall be removed and reset properly, except that if found to be high they may be driven to the proper elevation provided the tops of the posts are protected by suitable driving caps.

Wood guard rail posts and guard posts may be erected by driving or by a combination of drilling and driving when after demonstration at the project site the Engineer approves the results as being equal to or better than the results that can be obtained by erecting posts in drilled holes and backfilling. Acceptability of driving or combined drilling-driving will be contingent on the following conditions:

- (a) Use of approved and proven mechanical driving equipment;
- (b) Maintenance of acceptable results without impairing the structural integrity of adjacent materials or structures;
- (c) Use of drills to penetrate courses that may resist penetration by driving. When drills of nominal post-size are used the void between the post and the edge of the hole shall be filled with Grade AC-13 asphalt. Holes larger than nominal post-size drilled through paved surfaces or cement treated courses shall be properly backfilled with hot or cold bituminous pavement;
- (d) Out-of-tolerance posts shall be pulled and properly replaced or reset, and all disrupted portions of the roadbed structure restored as directed; and

- (e) Mutilated posts shall be pulled and properly replaced, and all disrupted portions of the roadbed structure restored in kind or as directed.

Steel guard rail posts may be erected by driving, provided an approved driving head is used.

The top inside edges of posts shall be set within 1/4 inch of correct vertical and horizontal alignment.

Guard rail posts on bridges shall be plumb and accurately spaced and lined.

Where sections of rail are located on curves, the posts shall be erected so as to obtain the designated panel lengths measured along the face of the rail.

**606.03.2--Anchorage.** Anchors and braces shall be furnished and placed as shown on the plans.

**606.03.3--Erection of Rails.** All fabrication and forming of rail elements shall be completed prior to application of the shop paint. Field punching, cutting, burning, or welding will not be permitted, except where specifically authorized by the Engineer and subject to the conditions thereof.

The rail shall be erected in a manner resulting in a smooth, continuous, taut rail conforming to the line and grade shown on the plans or established. In the erection of rail, consideration shall be given to the prevailing temperature and the anticipated rise and fall of temperature ultimately affecting the length of the rail.

Where required, ends of rail shall be flared within the limits shown on the plans or established.

Bolts and clips used for fastening rails or fittings to posts shall be drawn up tightly, and all bolts, except "take up" device bolts, shall be of such length as to not project beyond the nut more than the limits shown on the plans. Sawing of ends of bolts to meet this requirements will be permitted.

**606.03.4--Repairing Rails and Fittings.** Where the galvanizing on guardrail or fittings has been damaged, the coating shall be repaired by re-galvanizing or the surface repaired by painting with two coats of zinc oxide paint approved by the Engineer.

**606.03.5--Reflectors.** Reflector units shall be installed in conformity with details shown on the plans and in accordance with the manufacturer's recommendations. Where holes are required to be bored in posts or other units, the holes shall be bored prior to the required painting. The reflectors shall be installed after all painting is completed.

**606.04--Method of Measurement.** Guard rail will be measured by the linear foot along the face of the rail from center to center of end posts for each complete section and will include posts and other elements of the completed section.

Special sections will be measured per each or linear foot, as indicated on the plans.

Guard posts will be measured by the unit per each post installed. Such measurement will include reflectors as specified, backfill, clean up, and any required additional hardware such as caps and chain necessary to complete the work.

**606.05--Basis of Payment.** Guard rail will be paid for at the contract unit price per linear foot for each designated type. Special sections will be paid for at the contract unit price per linear foot or per each, as applicable. Guard posts will be paid for at the contract unit price per each.

These prices shall be full compensation for completing the work.

Payment will be made under:

606-A: Guard Post	- per each
606-B: Guard Rail, <u>Designation</u>	- per linear foot
606-C: Guard Rail, Cable Anchor, <u>Designation</u>	- per each
606-D: Guard Rail, Bridge End Section, <u>Designation</u>	- per each
606-E: Guard Rail, Terminal End Section	- per each
606-F: Special Sections, <u>Designation</u>	- per linear foot or each

**SECTION 607 - FENCES AND CATTLE GUARDS**

**607.01--Description.** This work consists of furnishing materials and constructing fences, gates, and cattle guards in accordance with the plans and these specifications and in reasonably close conformity with the lines and grades indicated on the plans or established. Fencing shall include satisfactory connections with all intersecting fences, bridges, and culvert headwalls.

This work also consists of fencing designed and constructed primarily as screening or glare barrier. In this case certain modifications or amendments to these specifications shall be made as shown on the plans or in the proposal; otherwise, the requirements of these specifications shall be applicable.

**607.02--Materials.**

**607.02.1--Type "A" Fence.** Materials for Type "A" fence shall meet the requirements of the following subsections:

Woven Wire (Hog Wire) .....	712.03
Barbed Wire .....	712.02
Staples .....	712.15
Tension Wire .....	712.14
Tie Wire .....	712.13

**607.02.2--Chain Link Fence.** Materials for chain link fence shall meet the requirements of Subsection 712.04.

**607.02.3--Posts and Lumber.** The size of posts and lumber shall be as designated on the plans.

Unless otherwise specified, concrete posts for Type "A" fence shall be used in interchange areas. In other areas, either wood or concrete posts for Type "A" fence may be used, provided the same type is used throughout the project.

Posts shall meet the requirements of Subsection 712.05 for the type specified or permitted.

**607.02.4--Gates.** Gates shall meet the requirements of Subsection 712.12 for the type specified.

**607.02.5--Concrete for Anchors and Footings.** Concrete for anchors and footings shall be Class "C" conforming to the requirements of Section 804, except that the requirements for size and gradation of aggregate may be modified, and small, one-half cubic yard or less, batches may be mixed by approved hand methods.

**607.02.6--Cattle Guards.** Materials for cattle guards will be specified on the plans and in the special provisions.

**607.03--Construction Requirements.**

**607.03.1--General.** The Contractor shall perform the clearing and grubbing necessary to construct the fence to the required grade and alignment. Clearing and grubbing shall be in accordance with Section 201.

A herbicide shall be used for sprout control of cut stumps. Paint or spray freshly cut stump surface thoroughly covering cambium area next to bark until the herbicide runs down around the root collar. Treat stump as soon as practical after cutting for more effective control but no later than day of cutting except when

spraying must be postponed due to inclement weather. Pine stumps and all other stumps larger than 15 inches in diameter do not require spraying for control of sprouting. Permissible herbicides are 2,4-D (amine); picloram +2,4-D; ammonium sulfamate; and dicamba. Specific requirements such as mixing, diluting, rate, application, use restrictions, safety precautions, etc. will be in accordance with the manufactures printed container label.

Re-spraying will be required when the herbicide is washed off by rain within eight hours of application or diluted to such an extent to be ineffective.

At locations where breaks in a run of fencing are required, or at intersections with existing fences, appropriate adjustment in post spacing shall be made to conform to the requirements for the type of closure indicated.

All posts shall be set plumb and to the required grade and alignment. Cutting of the tops of the posts will be allowed only with the approval of the Engineer and under the conditions specified by the Engineer.

Wire or fencing shall be stretched taut and firmly attached to posts and braces by the method indicated on the plans. All wire shall be installed to the required elevations.

At each location where an electric transmission, distribution, or secondary line crosses the fence, the fence shall be grounded by a copper-coated steel rod at least eight feet long and at least 1/2 inch in diameter. The rod shall be installed directly below the point of crossing and driven vertically until the top is six inches below the ground surface. A No. 6 solid copper conductor or equivalent shall be used to connect each fence element to the grounding rod. The connections shall be either brazed or fastened with approved non-corrosive clamps.

When a power line runs parallel or nearly parallel to the fence, the fence shall be grounded at each end or gate post or at intervals not to exceed 1,500 feet.

Fences shall generally follow the contour of the ground, with the bottom of fence fabric not less than one inch nor more than six inches from the ground surface. Grading shall be performed where necessary to provide a neat appearance. Where abrupt changes in the ground profile in low areas make it impractical to maintain the ground clearance shown on the plans, longer posts may be used and multiple strands of barbed wire stretched thereon. The vertical clearance between strands of barbed wire shall be as shown on the plans.

On tangent sections fabric or wire shall be placed on faces of posts opposite the highway, and on curve sections on the faces of posts opposite the center of curvature.

**607.03.2--Concrete and Timber Posts.**

**607.03.2.1--General.** Post holes shall be of sufficient diameter to allow proper compaction of backfill. The backfill shall be made with the best soil available and shall be thoroughly tamped until the post is firm and rigid in position.

Round wood posts shall be set with the large end down and shall be plumbed to within a tolerance of 1/4 inch per foot of height. The top shall be set to within 1/2 inch of the specified alignment on the side to which the wire is to be attached.

Concrete and square wood posts shall be set plumb and to within 1/2 inch of the specified alignment on the side to which the wire is to be attached.

Fence posts not specified to be set in concrete may be erected by driving, drilling, or combination, when after demonstration at the project site the Engineer approves the results as being equal to or better than what can be obtained by erecting in dug holes and backfilling.

The use of mechanical driving equipment shall not require removal of more desirable trees or more grading than is required for dug holes.

**607.03.2.2--Line Posts.** When specified or directed, line posts at the low point of a grade or in depressions where the pull on the fence tends to lift the post shall be anchored in concrete.

**607.03.2.3--Brace Bays.** When the distance between end, gate, or corner posts exceeds 500 feet on tangent fences and 250 feet on curved fences, brace bays shall be erected.

**607.03.2.4--Concrete Anchors.** The surface of concrete anchors shall be shaped to drain away from the post. Anchors shall be covered with suitable earth and allowed to cure five days before installation of wire or fabric.

**607.03.3--Metal Posts and Concrete Footings.** Unless otherwise specified or permitted, holes for concrete footings shall be wetted sufficiently to prevent absorption of moisture from concrete. The concrete shall be finished above the ground to shed water and covered with four inches of loose earth. The footings shall be allowed to cure for seven days before erection of fabric.

When the ground is not firm, side forms will be required. Forms may be removed within 24 hours. Immediately after stripping the forms, moistened earth shall be tamped solidly around the footing, and four inches of loose earth shall be placed over the footing.

The distance between end, corner, intermediate brace, or gate posts shall not exceed 1,000 feet, and each such post shall be braced and trussed to the adjacent



line posts.

If specified, metal posts shall be erected without concrete footings. In this case, posts shall be driven plumb to within 1/2 inch of the specified alignment by means of an approved post driver. Posts which are bent or otherwise damaged shall be removed and replaced.

#### **607.03.4--Installing Wire.**

**607.03.4.1--Woven Wire Fabric.** Stretching shall be with an approved stretcher that will produce approximately equal tension in each line wire. The fabric shall be stretched until the tension is just below the point of producing displacement in the tension crimps. At each end, corner, or gate post, each strand of line wire shall be wrapped around the post and securely fastened by winding the free end around the wire near the post. Splicing shall be accomplished by the use of either a wrapped splice or a corrosion resistant, compressed sleeve type splice meeting the approval of the Engineer. When a wrapped splice is used, the vertical wires adjacent to each end shall be brought together and the end of each horizontal wire wrapped with at least six complete turns around the other corresponding horizontal wire.

**607.03.4.2--Barbed Wire.** Either a wrapped splice or the compressed sleeve type splice described above may be used for barbed wire. When the wrapped splice is used, each end shall be wrapped with at least six complete turns around the other wire.

**607.03.4.3--Chain Link Fabric.** Continuous mesh shall be afforded by weaving and fastening rolls of fabric together with a single wire strand of the size and type in the fabric.

**607.03.5--Gates.** Posts and footings or anchorages shall be installed in the manner prescribed for the post type used.

When the type latching device so requires, a concrete "keeper" or footing, minimum 12 x 12 x 15 inches of the type necessary to seat the drop-bar firmly, shall be constructed.

**607.03.6--Finished Fence.** The tops of all posts shall be at a uniform grade and at a uniform distance above the top wire.

All surplus excavated material and debris resulting from construction shall be disposed of as directed and the fence left in a neat and orderly condition.

**607.03.7--Cattle Guards.** Construction details for cattle guards will be set out in the special provisions.

**607.04--Method of Measurement.** Type "A" woven wire fence, of the height specified, will be measured by the linear foot of completed fence which includes woven wire, barbed wire, and other appurtenances shown on the plans. Measurement will be made along the bottom of the woven wire fabric, and openings will be excluded from the measurement.

Chain link fence, of the height specified, will be measured by the linear foot of completed fence. Measurements will be made along the bottom of the chain link fabric, and openings will be excluded.

Barbed wire fence of the number of strands specified will be measured by the linear foot of completed fence. Measurements will be made along the completed fence, and openings will be excluded.

Single strand barbed wire indicated for separate payment will be measured by the linear foot.

Gates will be measured by the unit.

Posts, including tops and footings of metal posts, will be measured by the unit.

Concrete anchors for use with timber or concrete posts will be measured by the unit.

Pickets will be measured by the linear feet of completed fence containing pickets. Lattice will be measured by the linear feet of completed fence containing lattice.

Cattle guards will be measured per each.

Excavation and backfill for footings, anchorages, and cattle guards; stretcher bars; top rails; post tops; barbed wire integral to specified fences; bottom tension wires or rails; tie wires; tension wires; truss rods with turnbuckles; connectors; bands; compression braces; hinges; latching devices; hardware; reflectors; paint; painting; and other accessories and incidentals necessary to complete the work will not be measured for separate payment.

Required clearing and grubbing and grading will not be measured for separate payment unless so indicated on the plans.

**607.05--Basis of Payment.** Fencing items will be paid for at the contract unit prices for the respective items, which shall be full compensation for completing the work.

Payment will be made under:

607-A: \_\_\_\_" Type "A" Woven Wire Fence

- per linear foot

Section 607	Section 607
607-B: ____” Type ____ Chain Link Fence *	- per linear foot
607-C: ____” Type ____ Chain Link Fence, <u>Glare Barrier / Screening</u>	- per linear foot
607-D: Barbed Wire Fence, <u>No. Strands &amp; Materials</u>	- per linear foot
607-E: Barbed Wire, Single Strand	- per linear foot
607-G: Gate, <u>Size &amp; Type</u> *	- per each
607-H: Pickets, <u>Height, Size and Material</u>	- per linear foot
607-L: Lattice, Height, <u>Size, Material, etc.</u>	- per linear foot
607-P1: Line Posts, <u>Length, Size &amp; Material</u>	- per each
607-P2: Brace Posts, <u>Length, Size &amp; Material</u>	- per each
607-P3: Gate Posts, <u>Length, Size &amp; Material</u>	- per each
607-W: Cattle Guards	- per each
607-Z: Concrete Anchors	- per each

\* Indicate when arms with barbed wire is required

## SECTION 608 - CONCRETE SIDEWALKS

**608.01--Description.** This work consists of constructing portland cement concrete sidewalks on a prepared subgrade in accordance with the plans and specifications. Lines and grades shall be as shown on the plans or established. "Subgrade" in this section shall mean the prepared foundation on which the sidewalk is constructed.

**608.02--Materials.** All material furnished for use shall comply with appropriate requirements of the 700 series of these specifications, and the following:

Concrete shall be Class B meeting the requirements of Section 804 or Class P or PA meeting the requirements of Section 501.

Reinforcing steel shall meet the applicable requirements of Sections 602 and 711 and plan details.

**608.03--Construction Requirements.**

**608.03.1--Equipment.** The Contractor may use forms or, if requested in writing and approved by the Engineer, an approved automatic extrusion type paving machine.

Forms shall be wood or metal. If wood, they shall be dressed on all sides, and be free of bulges, warps, and loose knots. If metal, they shall be of approved section and have a flat surface on top. The depth of the forms shall be equal to the depth of the sidewalk. Adequate means shall be provided for securely fastening the ends of forms together.

Prior to use, an automatic extrusion machine must be demonstrated to produce a consolidated concrete section conforming to the dimensions, cross section, line, and grades shown on the plans or established.

**608.03.2--Excavation and In-Grade Preparation.** Excavation shall be made to the required depth and to a width that will permit the installation and bracing of forms. The foundation shall be shaped and compacted at the proper moisture content to a firm, even surface conforming to the lines, grades, and sections shown on the plans or established. All soft, spongy, or other unsuitable materials encountered shall be removed and replaced with acceptable material.

**608.03.3--Setting Forms.** Forms shall be set to the required line and grade and rigidly held in place by stakes or braces. Ends of adjoining form sections shall be flush. Forms and division plates shall be cleaned and oiled before placing concrete against them.

**608.03.4--Handling, Measuring, Proportioning, and Mixing Materials.** The method of handling, measuring, proportioning, and mixing concrete materials shall conform to Section 501 or Section 804. Where reinforcement is required, it shall be placed in accordance with Section 602.

**608.03.5--Placing Concrete.** A template resting upon the side forms and having its lower edge at the elevation of the subgrade shall be drawn along the forms to shape and grade the subgrade before concrete is deposited. The subgrade shall be moist and free of debris and foreign material before concrete is deposited upon it. The concrete mixture shall be placed on the prepared subgrade to the depth required to complete the sidewalk in one course. It shall then be vibrated and/or tamped and struck off with an approved straightedge resting upon the side forms and drawn forward with a sawing motion. The surface shall be given a Class 6 float finish as set out in Section 804.

The edges of sidewalk shall be rounded with an edging tool having a radius of 1/2 inch. Expansion joints shall be edged with an edger having a radius of 1/4 inch.

**608.03.6--Joints.** Expansion joints shall be of the dimensions specified and shall be filled with the type of premolded expansion joint filler specified. Sidewalks shall be divided into sections by dummy joints formed by a jointing tool or other acceptable means. These dummy joints shall extend into the concrete for at least one inch and shall be approximately 1/8 inch wide. Joints shall match as nearly as possible adjacent joints in curb or pavements. Dummy joints may be sawed in lieu of forming with a jointing tool.

Construction joints shall be formed around all appurtenances such as manholes, utility poles, etc. extending into and through the sidewalk. Premolded expansion joint filler 1/4 inch thick shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete sidewalks and fixed structure such as a building or bridge. This expansion joint material shall extend for the full depth of the walk.

**608.03.7--Protection and Curing.** Concrete shall be protected and cured in accordance with the requirements of Subsection 501.03.20 or by other approved methods.

Placement, protection, and curing of concrete during cold or hot weather shall conform to the limitations, conditions, and requirements set out in Section 804.

**608.03.8--Backfilling and Cleaning Up.** When the concrete has set sufficiently, the sides of the walk shall be backfilled and compacted to the required elevation with suitable material. All surplus material shall be disposed of as directed, and the completed work and the site shall be left in a neat and presentable condition.

**608.04--Method of Measurement.** Concrete sidewalks of the type specified will be measured for payment by the square yard.

Excavation, backfill, expansion joint material, and other miscellaneous items will not be measured for separate payment.

**608.05--Basis of Payment.** Concrete sidewalks will be paid for at the contract unit price per square yard, which shall be full compensation for completing the work.

Payment will be made under:

- |   |                   |
|---|-------------------|
| 608-A: Concrete Sidewalk, Without Reinforcement | - per square yard |
| 608-B: Concrete Sidewalk, With Reinforcement    | - per square yard |

## **SECTION 609 - CONCRETE GUTTER, CURB, AND COMBINATION CURB AND GUTTER**

**609.01--Description.** This work consists of constructing curb, gutter, and combination curb and gutter in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions, and cross sections shown on the plans or as established.

**609.02--Materials.** Concrete for detached curb, gutter, and combination curb and gutter shall meet the requirements of Section 601. Concrete for curbs integral with concrete pavement shall meet the requirements of Section 501.

Mixtures for bituminous curb shall be in accordance with Sections 401 and 403 and, unless otherwise specified or approved, shall be a Type ST, 12.5 mm mixture.

### **609.03--Construction Requirements.**

**609.03.1--Excavation and In-Grade Preparation.** Excavation and in-grade preparation for gutter, curb, and combination curb and gutter shall be performed in accordance with the applicable provisions of Section 321.

### **609.03.2--Cast-in-Place Portland Cement Concrete.**

**609.03.2.1--Forms.** Forms, except for divider plates and templates, may be wood or metal. All forms shall be full depth, straight, and free of warp and shall be securely staked, braced, and sufficiently tight to prevent leakage of mortar. All forms shall be cleaned thoroughly and oiled before placing concrete against them.

Lumber for wood forms shall be sound, free of bulges, loose knots, and warps, and of uniform width. All lumber shall be dressed commercial lumber at least two inches thick, except the Engineer may permit the use of flexible material on short radii.

Metal forms shall be of approved sections and shall have a flat surface on top. They shall present a smooth surface and be of sufficient strength when braced to withstand the weight of the concrete without bulging or displacement. Special care shall be exercised to keep metal forms free from rust, grease, or other foreign matter which would discolor the concrete.

Metal templates or dividing plates shall be of sufficient thickness and of such design as to hold the forms rigidly in place and to produce a smooth vertical joint after the plates are removed. They shall be of the full dimensions shown on the plans for curb, gutter, or combination curb or gutter.

**609.03.2.2--Proportioning, Mixing, and Placing Concrete.** Unless otherwise specified, concrete used for detached curb, gutters, and combination curb and gutter shall be Class "B" proportioned, mixed, and placed in accordance with the provisions of Section 601.

Concrete used for curb integral with concrete pavement shall be proportioned, mixed, and placed in accordance with the provisions of Section 501.

The concrete shall be placed on a moist grade and consolidated by vibration or other acceptable methods. Weep holes shall be placed through curbs where indicated on the plans or as directed.

**609.03.2.3--Extruded Construction.** Concrete curb and curb and gutter may be constructed by the use of a curb forming machine. Such a machine shall conform to (a), (b), and (e) of Subsection 609.03.3.2, and in addition, its continued use shall be contingent upon it producing curb with the specified section, line, and grade. If these conditions cannot be met, construction shall be by conventional methods.

In the event a curb forming machine is used, minor modifications in the concrete mix design may have to be made to improve placement, subject to approval of the State Materials Engineer.

**609.03.2.4--Sections and Joints.** Concrete curb, gutter, or combination curb and gutter shall be constructed in uniform sections of the length specified on the plans. These lengths may be reduced where necessary for closure but no section less than six feet will be permitted. The templates shall be accurately set before placing the concrete and allowed to remain in place wherever possible until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place.

Expansion joints shall be formed of premolded joint filler of the specified thickness, and shall be placed in line with expansion joints in the adjoining pavement or structure and at other locations designated on the plans. All joint fillers shall be cut to full cross section and shall extend for full depth, width, and length. All expansion joint material protruding after the concrete is finished shall be trimmed as directed. Immediately after removal of forms, the outer edges of filled joints shall be carefully exposed.

**609.03.2.5--Finishing.** The concrete shall be finished smooth and even by an approved float. Forms on the face of curbs shall be removed as soon as the concrete will hold its shape, and the surface shall be finished with a float to a smooth even texture. Plastering will not be permitted. Strike-off templates of the form and shape of the gutter shall be used to shape the top surface of gutters. Before final finishing the surface of gutters shall be checked with a 10-foot straightedge, and all irregularities of more than 1/8 inch in 10 feet shall be

corrected.

Edges on the faces of curbs shall be rounded with finishing tools having the radii shown on the plans. Edges where templates have been removed or expansion joint material has been placed shall be finished with an edging tool having a radius of 1/4 inch. All exposed surfaces against which some rigid type of construction is to be made shall be left smooth and uniform so as to permit free movement of the curb, gutter, or combination curb and gutter.

All tool marks shall be removed with a wetted brush or wood float. The finished surface shall be a uniform color free from discolorations.

**609.03.2.6--Protection and Curing.** Concrete shall be cured for at least 72 hours. Curing shall be by moist cotton or burlap mats, waterproof paper, white polyethylene sheeting, straw curing as set out in Subsection 501.03.20, or by other approved methods.

The Contractor shall have materials available at all times for the protection of unhardened concrete against rain. During the curing period all traffic, both pedestrian and vehicular, shall be kept off the concrete. Vehicular traffic shall be kept off for such additional time as the Engineer may direct. The Contractor shall protect the work from damage until release of maintenance. All sections which are damaged before release of maintenance shall be removed and reconstructed by the Contractor without extra compensation.

### **609.03.3--Bituminous Curbing.**

**609.03.3.1--Preparation of Bed.** When curbing is to be constructed on a newly placed bituminous surface, the curb may be laid if the surface is clean.

When curbing is to be constructed on concrete or bituminous pavement that is not newly placed, the bed shall be thoroughly swept and cleaned by compressed air. The surface shall be dry, and immediately prior to placement of the curb shall be tacked with bituminous material of the type and grade approved by the Engineer. The rate of application of the tack coat material shall be between 0.05 to 0.15 gallons per square yard of surface. The Contractor shall prevent the tack coat material from spreading to areas outside that to be occupied by the curb.

**609.03.3.2--Placing.** Bituminous curbing shall be constructed with a self-propelled curbing machine or paver with curbing attachments designed to extrude and compact the material in accordance with the typical section on straight and curved alignments.

The automatic curb machine shall meet the following requirements and shall be tentatively approved prior to its use. Its continued use shall be contingent upon its production of curbing meeting the specified requirements.



- (a) The weight of the machine shall be such that the required compaction is obtained without the machine riding above the specified grade.
- (b) The machine shall be capable of laying the curb to the dimensions and position specified.
- (c) The machine shall be capable of ironing the curbs smoothly with a heat-jacketed mold and of compacting the curb to at least 90 percent of theoretical density.
- (d) When curbing is to be placed on an existing bituminous surface the machine shall be capable of preheating the surface.
- (e) The machine shall form curbing that is uniform in texture, shape, and density.
- (f) The Engineer may permit construction by other means for short sections, sections with short radii, or for other reasons warranted by the Engineer. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine.

**609.03.3.3--Painting.** When painting is required, it shall consist of two coats of the specified traffic paint meeting requirements of Section 625. Glass beads shall also conform to the requirements of Section 625 and shall be applied onto the top coat of paint in a manner that will embed the beads sufficiently to adhere to the painted surface.

**609.03.4--Backfilling and Cleaning Up.** After the concrete has set sufficiently or the bituminous curb has cooled, the areas on the sides of the curb, gutter, and combination curb and gutter shall be filled to the required elevation with the specified materials and compacted as specified or directed.

All surplus material shall be disposed of as directed, and the entire area shall be left in a neat and satisfactory condition.

**609.04--Method of Measurement.** Concrete gutter, curb, combination curb and gutter, and bituminous curb will be measured by the linear foot along the face of the curb or flow line of the gutter. Deduction will be made for driveway openings.

Concrete integral curb, complete in place, will be measured by the linear foot along the face of the curb including the full length of curb returns for driveways.

No deduction in length will be made for drainage structures such as catch basins and inlets installed in the curbing.

Excavation, backfill, expansion joint material, and other related miscellaneous items will not be measured for separate payment. The cost thereof shall be included in the unit prices bid for other items.

**609.05--Basis of Payment.** Concrete gutter, curb, combination curb and gutter, and bituminous curb will be paid for at the contract unit prices per linear foot, complete in place, which shall be full compensation for completing the work.

Payment will be made under:

- 609-A: Concrete Gutter, Designation - per linear foot
- 609-B: Concrete Curb, Type \_\_\_\_ - per linear foot
- 609-C: Concrete Integral Curb, Type \_\_\_\_ - per linear foot
- 609-D: Combination Concrete Curb and Gutter \* - per linear foot
- 609-E: Bituminous Curb - per linear foot
- \* Type may be specified

**SECTION 610 - DRAINAGE WICKS**

**610.01--Description.** This section shall cover the work of furnishing and installing drainage wicks of the types, sizes and at the designated locations, all in accordance with the details specified on the plans and in these specifications or as directed by the Engineer.

This section shall also cover the work of drilling holes through the embankment layer at locations specified on the plans or directed by the Engineer. Jetting methods will not be permitted.

The Engineer may vary the depths, spacings or number of drainage wicks to be installed, and may revise the plan limits for this work as necessary.

**610.02--Materials.** The drainage wick shall be a prefabricated type composed of a drainage plastic core wrapped in a non-woven geotextile. The core shall be fabricated with suitable drainage channels.

The non-woven geotextile wrap shall meet the following minimum specifications:

<u>Property</u>	<u>Value</u>	<u>Test Method</u>
Tensile Strength	30 lbs./in.	ASTM Designation: D 4632
Permittivity	0.15 sec <sup>-1</sup>	ASTM Designation: D 4491

The core material shall be constructed in such a manner that the filter geotextile has a minimum surface area of 3.50 square inches per inch that is not in contact with the core material. The core channels shall have a minimum free volume of 0.16 cubic inch per inch.

The Contractor will be required to furnish to the Engineer three copies of a certified test report from the producer, showing all data required to indicate compliance with the above specifications and with certification that the material meets such specifications.

The certifications by the manufacturer or distributor will be prima-facie evidence of the materials meeting the specified requirements. All drainage wick materials will, however, be subject to approval by the Engineer.

### **610.03--Construction Requirements.**

**610.03.1-- Equipment.** In general, it shall be the Contractor's responsibility to select the proper sizes and amount of equipment to provide the desired results, but the following basic items shall be provided. The type of carrier to be used will depend upon the desired installation force, but it shall be equipped with a mandrel or sleeve of minimum cross sectional area not to exceed fourteen square inches which will protect the wick material from tears, cuts and abrasions during installation.

The Contractor shall secure approval of all equipment prior to beginning work and any equipment found unsatisfactory shall be promptly replaced or supplemented. All equipment approved for use shall be on a trial basis, and should after a short test section the equipment prove unsatisfactory, it shall be removed, replaced or supplemented as deemed necessary to accomplish the desired results.

**610.03.2--Installation.** At least two weeks prior to the installation of the drainage wicks, the Contractor shall submit to the Engineer for review and approval, details of the sequence and method of installation. Approval by the Engineer of the sequence and method of installation shall not constitute necessarily, acceptance for the duration of the project. If, at any time, the Engineer considers that the method of installation does not produce a satisfactory drainage wick, the Contractor shall alter the installation method and/or equipment as necessary to comply with these specifications.

The Contractor will be permitted to use augers or other approved methods to loosen stiff upper soils prior to the installation of the drainage wicks. These holes shall have a maximum diameter just large enough to permit the mandrel or sleeve carrying the wick and wick anchorage to penetrate the embankment and shall extend not more than two feet into the underlying highly compressible soil. The drainage wick shall be installed at the designated locations using a mandrel

or sleeve which completely encloses the drainage wick, thereby protecting it from tears, cuts and abrasions during installation. The mandrel, with the wick inside, shall be forced vertically into the ground to an elevation specified on the plans or directed by the Engineer. The mandrel shall be retracted leaving the wick in place to function as a vertical drain. The wick shall be cut neatly at its upper end with an eight-inch length of wick material protruding above the existing embankment surface.

The equipment shall be carefully checked for plumbness prior to advancing each wick and must not deviate more than one inch per foot from the vertical. Wicks that are out of their proper location by more than six inches, damaged in construction or improperly completed shall be rejected by the Engineer, and no compensation will be allowed for said rejected wicks.

The Contractor shall provide a suitable means of making a linear determination of the depth of the drainage wick at any given time and of the quantity of wick material used at each vertical drain location.

The Contractor shall observe precautions necessary for protection of instrumentation devices and shall replace at no additional cost to the State any equipment that is damaged or becomes unreliable as a result of the Contractor's operations.

Embankment or surcharge to be placed over an area in which drainage wicks are installed shall be allowed to settle the period of time as specified on the plans. In the case of bridge approach embankment fills, no end bent piling may be driven until the specified waiting period has elapsed. The waiting period begins when the total embankment and/or surcharge has been constructed to grade.

If no settlement monitoring devices are specified on the plans, the Contractor may propose to provide, install and maintain subsidence/settlement plates and essential appurtenances for the Engineer to measure the amount of settlement that occurs. If the data taken from these settlement plates shows that the amount of settlement is sufficient, or that the rate of settlement has declined to the point that little additional settlement will occur during the specified waiting period, the Contractor will be relieved of the total waiting period requirement. In the case of bridge approach embankment fills, the end bent piling may then be driven without further delay. The settlement measuring devices shall be approved by the Engineer.

**610.04--Method of Measurement.** Drainage wicks will be measured by the linear foot for the full length of drainage wicks, complete and in place. No separate measure for payment will be made for loosening of stiff upper soils by augering or other approved methods.

**610.05--Basis of Payment.** Drainage wicks, measured as prescribed above, will

be paid for at the contract unit price per linear foot, which price shall be full compensation for all drilling of holes, furnishing all materials, installation of drainage wicks and for all labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

610-A: Drainage Wicks

- per linear foot

## **SECTION 611 - BRICK MASONRY**

**611.01--Description.** This work consists of constructing brick masonry structures in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions, and details shown on the plans or as directed.

**611.02--Materials.** Masonry brick shall be new, whole brick of standard commercial size with straight and parallel edges and square corners. They shall be Grade SW or Grade SM as specified and shall meet the requirements of Subsection 706.01.

Unless otherwise specified, the following use requirements shall govern:

- (a) Grade SW brick shall be used in exposed masonry.
- (b) Grade SM brick shall be used in catch basins, inlets, manholes, and other sewer or drainage structures.

Mortar for brick masonry shall conform to the applicable requirements of Subsection 714.11.

### **611.03-Construction Requirements.**

**611.03.1--Excavation.** Excavation for brick masonry shall be performed in accordance with the provisions of Subsection 604.03.7.

**611.03.2--Laying Brick.** Brick masonry shall not be constructed in freezing weather or when bricks contain frost except by written permission of the Engineer and subject to the conditions set forth.

Brick for exposed surfaces, corners, etc. shall be selected for color and uniformity.

Mortar shall be mixed only in quantities required for immediate use. See Subsection 714.11.5 for more information on masonry mortar.

Brick shall be laid upon prepared foundations in accordance with the design indicated on the plans or as directed. All brick shall be thoroughly cleaned and saturated with water immediately prior to laying. They shall be laid in courses and in a manner that will thoroughly bond them into the fresh mortar by means of the "shove joint" method. "Buttered" or plastered joints will not be permitted. The arrangement of headers and stretchers shall be that which will thoroughly bond the mass. Unless otherwise specified, brick work shall be of alternate headers and stretchers with consecutive courses breaking joints. Other types of bonding, such as for ornamental work, will be specified on the plans.

All joints shall be completely filled with mortar. They shall not be less than 1/4 inch nor more than 1/2 inch in thickness, and the thickness shall be uniform throughout. All joints shall be finished properly as the work progresses, and on exposed walls they shall be neatly struck using the "weather" joint.

Bats or spalls shall not be used except for shaping around irregular openings or when unavoidable to finish out a course. When used to finish out a course, full bricks shall be placed at the corners and the bats placed in the interior course. Filling materials for the interior of the walls shall be the same quality as used in the face of the unit unless otherwise indicated on the plans or directed.

Weep holes shall be constructed as shown on the plans or as directed.

In case a brick is moved or the joint broken after laying, the brick shall be taken up, the mortar thoroughly cleaned from the brick bed and joint, and the brick relaid in fresh mortar.

In hot or dry weather, brick masonry shall be protected and kept wet for a period of at least 48 hours after the brick are laid.

Only expert bricklayers shall be used for this work, and all details of the construction shall be in accordance with approved and satisfactory practice.

All exposed masonry shall present an even, uniform, neat, and workmanlike appearance, and the exposed surfaces shall be thoroughly cleaned of all mortar and scars and the surface left the natural color of the brick.

**611.03.3--Backfill.** Backfill for brick masonry shall be in accordance with the provisions of Subsection 203.03.8.6.

**611.04--Method of Measurement.** Brick masonry will be measured by the cubic yard or by the thousand. The unit for measurement will be indicated on the bid sheet.

When measurement is by the cubic yard, the volume will include the mortar.

When measurement is by the thousand, the mortar will not be measured for payment.

When either concrete masonry or brick masonry is permitted under Subsection 604.03.4, measurement will be made in accordance with Subsection 604.04.

Excavation for brick masonry will not be measured for payment.

**611.05--Basis of Payment.** Brick masonry will be paid for at the contract unit price per cubic yard or per thousand, as indicated, which shall be full compensation for completing the work.

When brick masonry is used as an optional item of construction under Subsection 611.04, payment will be made as provided in Subsection 601.05.

Payment will be made under:

611-A: Brick Masonry - per cubic yard or thousand

### **SECTION 613 - ADJUSTMENT OF CASTINGS, GRATINGS, AND UTILITY APPURTENANCES**

**613.01--Description.** This work consists of furnishing all materials and adjusting existing catch basins, inlets, manholes and other designated structures in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions shown on the plans or as established.

**613.02--Materials.** New materials used in this construction, unless otherwise stipulated, shall conform to the requirements set out in Section 604.

#### **613.03--Construction Requirements.**

**613.03.1--General.** Construction requirements shall be, insofar as applicable, as described in Section 604. Castings, gratings, frames, covers, and other metal units shall be cleaned before resetting.

Where a casting, grating, or utility appurtenance is to be lowered, the masonry shall be removed to sufficient depth so that a set of proper dimensions may be reconstructed to receive the casting, grating or utility appurtenance at the new grade. Where the castings, grating or utility appurtenance is to be raised less than one foot, a new ring of masonry may be added without disturbing the old masonry. The use of metal rings to raise appurtenances will be allowed with approval of the Engineer. Where the distance to be raised exceeds one foot, the old masonry shall be removed to sufficient depth, as directed, to permit a neat and workmanlike extension to the new grade.

The Contractor shall replace, at no additional cost to the State, all units or parts indicated to be salvaged and reused which are damaged as a result of the Contractor's operation.

**613.03.2--Cleaning Up.** Upon completion of the adjustment, all surplus material shall be removed, and the structure and site of the work shall be left in a neat and clean condition. The entire structure shall be thoroughly cleaned of accumulations of silt, debris, or foreign matter of any kind and shall be kept clean until the final inspection.

**613.04--Method of Measurement.** Adjustment of castings, gratings, utility appurtenances, etc. for which pay items are included in the contract will be measured on a lump sum basis or by the number of units, as specified.

**613.05--Basis of Payment.** Adjustment of castings, gratings, and utility appurtenances for which pay items are included in the contract will be paid for at the contract lump sum price or at the contract unit price per each, as indicated, which shall be full compensation for completing the work.

Payment will be made under:

613-A: Adjustment of Castings, Gratings and Utility Appurtenances	- lump sum
613-B: Adjustment of Castings	- per each
613-C: Adjustment of Gratings	- per each
613-D: Adjustment of <u>Description</u>	- lump sum or per each

**SECTION 614 - CONCRETE DRIVEWAYS**

**614.01--Description.** This work consists of furnishing all materials and constructing cement concrete driveways on a prepared grade in accordance with these specifications, at the locations, and in reasonably close conformity with the lines, grades, and typical sections as shown on the plans or as established.

**614.02--Materials.** Unless otherwise stipulated, the materials used in this construction, in addition to conforming with the requirements of Division 700 for materials specified and used, shall conform to the following:

- (a) Concrete. The materials used in the manufacture of concrete shall conform to the requirements for the type of concrete pavement used in the roadway as set out in Section 501, or shall conform to the requirements for Class "B" concrete as set out in Section 804, as shown



on the plans and in the proposal, or as otherwise indicated in the contract.

- (b) Expansion Joint Filler. Expansion joint filler shall be either premolded or poured and shall conform to the requirements as set forth in Section 707 for the particular type specified.

### **614.03--Construction Requirements.**

**614.03.1--Equipment.** The equipment shall conform to the requirements of Section 501 or Section 804, as applicable. All small tools, such as edgers, floats, tamps, etc., shall be approved tools of such quality and quantity as to assure their adequacy in the performance of acceptable work. Approved equipment, necessary and required, shall be on the project in good working condition before construction will be permitted to start.

**614.03.2--Preparation of Grade.** In-grade preparation shall be performed in accordance with the applicable provisions and requirements of Section 321, unless otherwise specified or directed by the Engineer, within the tolerances set out in Subsection 321.03.7, extending such preparation, unless otherwise specified, to at least two (2) feet beyond the edges of the proposed concrete driveway.

**614.03.3--Forms.** Forms and forming shall conform with the requirements of Subsection 608.03.3.

**614.03.4--Manufacturing and Placing Concrete.** The concrete used in the construction of driveways shall be manufactured, proportioned and placed in accordance with the requirements of Section 501 or Section 804 as shown on the plans and in the proposal.

Prior to the placing of any concrete the grade shall be tested with a template cut true to cross-section of the proposed construction, all irregularities corrected and compacted, and the entire grade sprinkled with water.

Immediately after mixing, the concrete shall be deposited in a single layer on the moist grade to such depth that after finishing it shall be of the full thickness required. The edges, sides, etc., shall be thoroughly spaded, and the surfaces tamped sufficiently to compact the concrete and bring mortar, for finishing, to the surface.

Curb returns for driveways shall be constructed to the dimensions and section shown on the plans or as directed, using the same concrete mixture as used for the driveway slab. They shall be constructed monolithic with the slab as specified for integral curb in Section 609.

**614.03.5--Finishing.** The concrete shall be struck-off with a transverse template

resting upon the side forms, and shall be floated, with an approved float, in such a manner that excess water, laitance, or other inert material shall be removed from the surface. When the surface of the concrete is free from water and just before it obtains its set, it shall be finished with a wooden float so as to produce a sandy texture.

The edges of the concrete at expansion joints shall be edged with an edger having a radius of one-half (1/2) inch.

Curb returns shall be finished as specified for integral curb in Section 609.

**614.03.6--Expansion Joints.** Expansion joints shall be formed of premolded joint filler or poured filler of the specified thickness, and shall be placed at the locations indicated on the plans. All joint fillers shall be cut to full cross-section and shall extend to the full depth, width and length of the construction. Any expansion joint material extruding after the concrete is finished, shall be trimmed as directed.

**614.03.7--Protection and Curing.** After the concrete is completed, it shall be protected and cured in accordance with the requirements of Subsection 501.03.20 or other approved method.

Conditions governing the placement of concrete and the requirements for the placement, protection and curing of concrete during cold or hot weather shall conform to the limitations, conditions and requirements of Subsection 804.03.16 as applicable.

**614.03.8--Backfilling and Cleaning Up.** When the concrete has set sufficiently, the sides of the driveway shall be backfilled to the required elevation with suitable material, which shall be tamped in layers of not more than six (6) inches until firm and solid. All surplus material shall be disposed of as directed, and the completed work and the site shall be left in a neat and presentable condition.

**614.04--Method of Measurement.** Concrete driveways of the type specified will be measured for payment by the square yards. Driveway areas shall be defined as follows:

- (a) Where the driveway joins pavement and integral curb construction, the driveway area shall include the entire paved area back of the normal back of curb line.
- (b) Where the driveway joins combined curb and gutter construction, the driveway area shall include the entire paved area back of the normal line of the inside face of the gutter. The division line between combined curb and gutter and driveway area shall be that point designated as the beginning of the curb return.

**614.05--Basis of Payment.** Concrete driveways, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for curb returns; all backfilling and disposal of surplus materials; and for all materials, forms, equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

614-A: Concrete Driveway, Without Reinforcement \* - per square yard

614-B: Concrete Driveway, With Reinforcement \* - per square yard

\* Thickness may be specified

**SECTION 615 - CONCRETE BARRIER**

**615.01--Description.** This work consists of furnishing all materials and constructing concrete barrier in accordance with these specifications and the details shown on the plans and in reasonably close conformity with the dimensions, lines, grades, and elevations shown on the plans or established by the Engineer.

**615.02--Materials.** Materials used in this work shall be in accordance with the applicable requirements of Section 700 or as shown on the plans.

Unless otherwise specified, concrete for barrier, cast-in-place or slipform placement, shall be Class "B" meeting the requirements of Section 804.

Concrete for precast barrier using the dry-cast plant manufacturing process shall produce 5,000 psi compressive strength in 28 days.

**615.03--Construction Requirements.**

**615.03.1--General.** Cast-in-place barrier shall be constructed in accordance with the requirements of Subsection 813.03.2.2 and applicable requirements of Section 804.

Barrier constructed by slipform placement shall be constructed in accordance with the requirements of Subsection 615.03.2 and applicable requirements of Section 804.

Precast barrier shall be constructed in accordance with applicable requirements of Section 804 and the requirements of Subsection 813.03.2.3, except concrete material requirements will be as set forth in Subsection 615.02. Precast concrete barriers must meet the requirements of NCHRP Report 350.

Joints shall be as shown on the plans, and the surface finish shall be Class 2, rubbed or spray finish, in accordance with the requirements of Subsection 804.03.19.3.

**615.03.2--Slipform Placement.** When concrete median barrier is placed by the slipform method, the slipform machine shall be crawler mounted for stability and shall include automatic sensing and control equipment for controlling line and grade. Continuation of placement by the slipform method shall be contingent upon quality workmanship and good configuration, lines and grades with very little hand finishing required. The Contractor shall be fully responsible for placement at no additional cost to the State, any and all barrier not conforming with the requirements of the contract. To improve placement characteristics, the State Materials Engineer may make minor modifications in the concrete mix design for this type of placement.

**615.04--Method of Measurement.** Concrete barrier of the type specified will be measured by the linear foot out to out of the barrier. This measurement shall include all elements of the barrier and its foundation.

**615.05--Basis of Payment.** Concrete barrier, of the type specified, will be paid for at the contract unit price per linear foot, complete-in-place, which shall be full compensation for completing the work.

Payment will be made under:

- |  |                   |
|--|-------------------|
| 615-A: Concrete <u>Description</u> Barrier         | - per linear foot |
| 615-B: Precast Concrete <u>Description</u> Barrier | - per linear foot |

**SECTION 616 - MEDIAN AND ISLAND PAVEMENT**

**616.01--Description.** This work consists of constructing paved medians and islands on prepared grades in accordance with these specifications and in reasonably close conformity with the lines, grades, and sections shown on the plans or established. When so indicated on the plans, this work shall also consist of painting the surface, or portions thereof, of the median or island.

**616.02--Materials.**

**616.02.1--Concrete.** The materials used in the manufacture of concrete shall conform to the requirements of Section 804 for the class of concrete specified. Unless otherwise specified, Class "C" concrete shall be used.

**616.02.2--Joint Filler.** Joint filler shall be the type specified on the plans and shall conform to the requirements of Section 707. Unless otherwise specified,

the filler shall be ½-inch premolded filler meeting the requirements of Subsection 707.02.2.

**616.02.3--Hot Mix Asphalt Pavement.** Hot mix asphalt pavement shall be in accordance with the applicable materials and construction requirements of Sections 401 and 403.

**616.03--Construction Requirements.**

**616.03.1--Equipment.** The equipment shall conform to the applicable requirements of Sections 401, 501, and 804, except that approved modified placement, shaping, compacting, and finishing equipment will be permitted. All small tools, such as edgers, floats, tamps, etc., shall be approved tools of such quality and quantity as to assure their adequacy in the performance of acceptable work. Approved required equipment shall be on the project in good working condition before construction will be permitted to start.

**616.03.2--Preparation of Grade.** Unless otherwise specified, in-grade preparation shall be performed in accordance with the applicable provisions of Section 321. After completion of grade preparation, the entire area shall be treated with a soil sterilant as follows:

- (a) Soil sterilant material shall be applied at the maximum rate recommended on the manufacturer's label for perennial weed control. Any granular or pelletized type soil sterilant that is approved by the Engineer may be used. The approved material shall be uniformly spread over the entire area immediately prior to placing the pavement.
- (b) The chemical compounds shall be delivered to the job in unbroken containers with the manufacturer's label thereon.
- (c) The Contractor shall be responsible for performing all precautions as shown on the label of the containers and shall be liable for any injury or damage caused from handling or using the material until acceptance of the project.
- (d) Furnishing and placement of soil sterilant shall be absorbed in the cost of the other bid items.

**616.03.3--Forms.** Forms will not ordinarily be required. If specified or necessary, forms and forming shall be in accordance with the requirements of Subsection 608.03.3.

**616.03.4--Manufacturing and Placing Concrete.** Concrete for this work shall be manufactured and placed in accordance with the requirements of Section 501 or Section 804 except that approved modified methods of placement, shaping, and compacting will be permitted. Concrete surfaces shall be given a Class 6 float finish in accordance with Subsection 804.03.19.5.

The fresh concrete shall be deposited in a single layer on a moist grade. The edges, shall be thoroughly spaded, and the surface shall be tamped sufficiently to compact the concrete and bring mortar for finishing to the surface.

The finished surface shall conform closely to the typical section indicated on the plans and shall not have irregularities which would prohibit complete surface drainage, including drainage over adjacent curb.

The edges of the concrete at expansion joints shall be edged to a radius of 1/2 inch.

**616.03.5--Expansion Joints.** Unless otherwise shown on the plans, expansion joints shall be formed of premolded joint filler of the specified thickness. All joint fillers shall be cut to full cross section and shall extend to full depth, width, and length. All expansion joint material extruding after the concrete is finished shall be trimmed as directed.

In the event the locations are not shown on the plans, joints shall be placed between all edges of the median or island pavement and the surrounding curb or pavement. Where applicable, joints shall be placed to match expansion and contraction joints in adjacent curb or pavement.

**616.03.6--Protection and Curing.** After the pavement is finished, it shall be protected and cured in accordance with the requirements of Subsection 501.03.20 or by other approved method.

Placement, protection, and curing of concrete during cold and hot weather shall conform to the limitations, conditions and requirements of Subsection 804.03.16.

**616.03.7--Manufacturing and Placing Bituminous Pavement.** Hot mix asphalt pavement used in construction of median and island pavement shall be manufactured and placed in accordance with the requirements of Sections 401 and 403, except that approved modified methods of placement, shaping, and compacting will be permitted. The pavement shall consist of the layers and types shown on the plans. The surface of the finished pavement shall conform closely to the typical section indicated on the plans and shall not have irregularities which would prohibit complete surface drainage, including drainage over adjacent curb.

**616.03.8--Cleaning Up.** All surplus material shall be disposed of as directed, and the completed work and the site shall be left in a neat and presentable condition.

**616.03.9--Markings.** When specified, pavement markings on median and island pavement shall be made as detailed or as directed by the Engineer, and shall conform to the provisions and requirements of the applicable sections for the

markings specified.

**616.04--Method of Measurement.** Median and island pavement of the type specified will be measured in square yards.

Excavation will not be measured for separate payment, and the cost thereof is to be included in the price of other items of work.

Pavement markings, if required, will be measured and paid for in accordance with the applicable sections for the markings specified.

**616.05--Basis of Payment.** Median and island pavement of the type specified will be paid for at the contract unit price per square yard, which shall be full compensation for completing the work.

Payment will be made under:

616-A: Concrete Median and/or Island Pavement, Thickness - per square yard

616-B: Bituminous Median and/or Island Pavement, Thickness - per square yard

## SECTION 617 - RIGHT-OF-WAY MARKERS

**617.01--Description.** This work consists of furnishing and placing right-of-way markers in accordance with the plans and these specifications and at points designated on the plans, or as directed. The work also shall include the removal of right-of-way markers from their original locations and resetting at new locations as specified or established.

**617.02--Materials.** The materials used in this construction shall conform to the requirements of Subsection 706.04 or as indicated on the plans.

**617.03--Construction Requirements.**

**617.03.1--General.** Markers shall be manufactured in accordance with the details shown on the plans, and the requirements of this section.

Any required reinforcement shall conform to the details shown on the plans and the requirements of Section 602.

All letters, symbols, and other markings shall be as shown on the plans and shall be neatly imprinted in the markers.

The markers shall be set at the locations designated on the plans, or as directed by the Engineer. They shall be set to within 1/4 inch of the lines indicated or

established, even with the natural ground elevation, and in a vertical position within a tolerance of 1/8 inch per foot. Any required backfilling shall be made with suitable material thoroughly tamped in six-inch layers. All surplus material shall be disposed of as directed and the site shall be left in a neat and presentable condition.

The layout and placement of right-of-way markers shall be performed by, or under the supervision of, or directed by, a Registered Professional Engineer or Registered Land Surveyor who is duly registered and entitled to practice as a Land Surveyor in the State of Mississippi. The duties performed by said Registrant shall conform to the definitions under the practice of “land surveying” in Mississippi Law. The location of the markers shall be as shown in the plans, and as required to meet the minimum standards of surveying. The Contractor shall not engage the services of any person in the employ of the Department for the performance of any of the work covered by this Section or any person who has been employed by the Department within the past six months, except those who have legitimately retired from service with the Department during this period.

**617.03.2--Removal and Resetting.** Markers which are specified to be removed and reset shall be carefully removed and reset at the location indicated or established in accordance with the provisions and requirements of Subsection 617.03.1.

The Contractor shall replace without additional compensation all markers broken or damaged due to the removal and resetting operation.

**617.04--Method of Measurement.** Right-of-way markers, new and removed and reset, will be measured by the unit.

**617.05--Basis of Payment.** Right-of-way markers, new and removed and reset, will be paid for at the contract unit price per each, which shall be full compensation for completing the work.

Payment will be made under:

- 617-A: Right-of-Way Markers, Type \_\_\_\_\_ - per each
- 617-B: Right-of-Way Markers Removed and Reset - per each

**SECTION 618 - MAINTENANCE OF TRAFFIC AND  
TRAFFIC CONTROL PLAN**

**618.01--Description.**



**618.01.1--General.** This work consists of maintaining two-way through and local traffic at all times, except as provided herein or in other contract documents. It consists of constructing, maintaining in good condition, and removing temporary structures, approach roads, and other facilities required for maintenance of traffic and the furnishing of temporary materials therefore, unless otherwise indicated in the contract.

This work includes furnishing, erecting, maintaining in good condition, and removing all required construction signs, barricades, and temporary traffic stripe.

When specified on the plans, the Contractor will construct, maintain and remove all detour bridges as indicated in the plans and contract documents. This work shall consist of the furnishing of materials, construction, maintenance and removal of bridges with payment as described hereinafter.

Unless shown otherwise in the plans, through and local traffic shall be maintained throughout the project at all times on existing facility, detours and completed permanent facility indicated on the plans and as necessary to carry out construction within the intent of the plans and contract. Minimum requirements of the Traffic Control Plan are shown on the plans.

Upon receipt of the Final or Partial Maintenance Release, as documented in writing by the State Construction Engineer, the Contractor shall have fifteen (15) calendar days in which to remove all construction signs on the project. It is agreed that if the signs are not removed within the fifteen (15) calendar days the signs shall be considered abandoned and shall become the property of the Mississippi Transportation Commission which may remove, use, and/or dispose of such signs as it sees fit.

The Contractor shall place and maintain appropriate construction signs for any additional work on the project after the Maintenance Release, or Partial Maintenance Release, has been issued. These construction signs will not be measured for separate payment. Payment for these signs shall be included in pay item no. 618-A, Maintenance of Traffic.

**618.01.2--Traffic Control Plan.** This work also consists of complying with the contract requirements of the Department's Traffic Control Plan. The purpose of the Traffic Control Plan is to maintain through and local traffic safely through construction zones. In addition to this section, the plan includes: Subsections 104.04, 105.15, 107.07, and 107.10; Section 619; special provisions modifying this section and supplements thereto; individual plan sheets applicable to the plan; and Part VI of the Manual on Uniform Traffic Control Devices (MUTCD). All traffic control devices shall comply with Part VI of the latest edition of the MUTCD.

The Department will designate a responsible person at the project level to monitor the Contractor's compliance with the plan.

The Contractor shall also designate a responsible person whose primary duty shall be to monitor and maintain the effectiveness of the plan. The Engineer shall be furnished with the telephone numbers where the Contractor's responsible person and a substitute, authorized to act in the absence of the responsible person, may be reached at all times when not on the project. This in no way modifies the requirements of Subsection 105.05 regarding the assignment and availability of the superintendent.

The Engineer, or other appropriate personnel as required, will review and analyze accidents to determine if corrective action to the Traffic Control Plan is needed. In the event corrective action is indicated, the Contractor shall proceed immediately with same.

The location and spacing of signs shown on the traffic control plan are approximate and, with approval of the Engineer, may be adjusted as necessary to fit field conditions.

Because of the required work at the beginning and end of a project, it may be necessary to erect construction signs or lane closure signs outside the limits of the project.

**618.02--Materials.** Unless otherwise specified, the Contractor shall provide all materials for the construction and maintenance of detours required for the maintenance of traffic, except the Engineer may permit the Contractor to use excavation from the roadbed, or other designated sources, that is available at the time of construction of detours without detriment to the work and provided the excavation is ultimately placed in its final position in the roadbed in an uncontaminated condition. No additional compensation will be made to the Contractor for the extra handling of the material.

Unless otherwise specified, the applicable material requirements set out in the Division 700 and in Section 619, or in other contract documents, shall apply to all materials used in temporary traffic facilities. The Contractor shall select and use materials that with adequate maintenance or replacement will provide a satisfactory facility for the entire period the temporary facility is required.

### **618.03-- Construction Requirements.**

**618.03.1--General.** All detours shall be constructed and maintained in such a manner that they will adequately carry the traffic required.

Requirements for temporary traffic facilities shown on the plans, or set forth in these specifications, shall be understood to be the minimum requirements anticipated. Actual traffic conditions may require work or devices in addition to

those shown on the plans.

Traffic lanes shall be kept free of dust and, when deemed necessary, they shall be sprinkled with water, or some other dust palliative shall be applied.

Unless otherwise specified, temporary structures and roads shall be sufficiently strong to safely carry the load permitted on the highway under construction. Structures shall be provided with suitable curbs, rails, or other devices as required for the protection of traffic. Unless otherwise specified, walkways when required for pedestrians shall have a clear width of four feet, or as shown on the plans, and shall be protected from vehicular traffic in the manner specified or directed.

Unless otherwise specified, the Contractor shall remove all temporary detours, satisfactorily dispose of all surplus materials, grade, finish, and dress the disturbed areas to the required section, and complete all work incidental thereto prior to release of maintenance.

**618.03.2--Barricades, Signs, and Flaggers.** The Contractor shall construct, erect, maintain, clean, repair and replace as necessary all barricades, warning signs and other devices specified or ordered.

Flaggers shall be stationed at such points as may be deemed necessary. Movable construction signs shall be removed as their use becomes inapplicable. Placing temporary signs and their supports face down adjacent to the roadway will not be allowed.

The plans will usually contain a line diagram indicating the designation and location of construction signs which are to remain fixed in place for the duration of the maintenance period of the contract.

Such signs and all other signs and devices of a temporary nature shall be in accordance with Section 619, the plans, and the MUTCD, as applicable.

**618.03.3--Safe Movement of Traffic.** The Contractor shall limit construction operations to such length as necessary to meet the traffic handling requirements of the contract.

On two-lane roadways, traffic may be alternately routed over a single lane in such a manner as to provide safe movement of the traffic with minimum delay. In such case, flaggers will be required and, when deemed necessary, an approved pilot vehicle with sign meeting the requirements of the plan standards shall be provided and operated to control the speed and sequence of movement of the traffic.

A longitudinal pavement edge that traffic is expected to move across should have

an elevation difference of not more than 2¼ inches. If the pavement edge is more than 1½ inches and less than or equal to 2¼ inches, uneven pavement signs will be required as shown in the plans or contract documents. If the pavement edge is less than or equal to 1½ inches, no uneven pavement signs will be required. Transverse pavement joints shall be sufficiently tapered to allow for the safe movement of traffic.

When a paving operation produces a longitudinal pavement edge that traffic is expected to move across, the adjacent lane shall be constructed to eliminate any uneven pavement edge within 48 hours, unless prohibited by weather conditions or an emergency arises.

All failed areas that have been removed and all trenches shall be filled and compacted to the elevation of the existing pavement before work is discontinued for the day. In emergencies, the Engineer may permit the use of approved temporary materials for backfill, provided the temporary materials will be adequate to facilitate normal safe movement of traffic. Separate measurement for payment will not be made for the furnishing, placing, maintaining, removing, and disposing of such temporary materials.

Except under the following conditions, no portion of the roadway which is intended to be used for maintenance of traffic shall be blocked after work hours. In exceptional cases when all efforts have been made to restore the surface of the roadway and because of equipment failure or other uncontrollable causes complete restoration is not possible before work must be discontinued for that day, the Contractor shall provide adequate warning signals, barricades, other appropriate devices, and flaggers, appropriately placed or stationed for the protection of the public. The Engineer may also require the use of a pilot vehicle as provided herein.

The Contractor shall be required to place granular material on the shoulders at any time a differential of two and one-quarter (2¼) inches or more exists between the present pavement edge and the shoulder grade. This condition may exist prior to any preliminary leveling, after the placement of the preliminary leveling, after the placement of the surface course. In any event, whenever or wherever, a 2¼-inch differential exists between the pavement edge and the shoulder material, this condition shall be corrected by the placement of the shoulder material to correct the differential.

All centerline, lane lines, edge lines and no-passing stripes that have been covered or removed during the day's operations shall be replaced with temporary stripe before work is discontinued for the day or as soon thereafter as weather conditions will permit, except that:

- (1) Replacement of no-passing stripes may be delayed for a period not to exceed three (3) days for a two or three lane road.

- (2) Temporary edge lines may be eliminated on projects requiring shoulders constructed of granular material.
- (3) Temporary edge lines placed on the final pavement course of projects requiring paved shoulders without surface treatment shall be placed in the permanent stripe location, otherwise temporary edge lines on projects requiring paved shoulders may be placed on the adjacent shoulder in as near the permanent location as possible.

Temporary no-passing stripe is not considered a major item of work and such stripe which is eliminated because of placing the next course prior to expiration of the 3-day period shall not result in a monetary adjustment to the Contractor as provided in Subsection 104.02. All temporary stripe shall be placed in accordance with the plans and Subsection 619.03.2.

In addition to the temporary no-passing stripe, the Contractor shall erect standard "DO NOT PASS," "NO-PASSING ZONE," and "PASS WITH CARE" signs in accordance with plan details or as specified in the MUTCD. These signs shall be erected prior to the obliteration of the no-passing stripe and shall be maintained in good order until the Engineer permits their removal.

Permanent pavement markings are to be applied no sooner than 10 days nor later than 45 days after placement of the pavement. When shoulder paving or placement of granular material adjacent to the pavement edge is required and upon approval of the Engineer, the permanent edge stripe may be delayed until a section, not to exceed five miles, of the shoulder work is complete. When the project length is less than five miles, the edge stripe shall be placed no later than 15 days after completion of the adjacent shoulder.

Permanent pavement markings on surface treatment shall be delayed until the maximum amount of seal aggregate has embedded and all loose material is broomed from the surface. All temporary stripe shall be maintained in good order until placement of the permanent pavement markings or placement of the next pavement course or until removed. Maintenance of temporary stripe may require more than one application over the life of the project. Payment will be made for one application only.

**618.03.4--Contractor's Responsibility.** The Contractor shall be responsible for protection against loss or damage from any cause to all temporary structures including approaches, and shall maintain them in a satisfactory condition until their use is no longer required. If a temporary structure, or approaches, is damaged due to high water or other reasons, it shall be replaced by the Contractor at no additional cost to the State, except that for temporary structure and approaches constructed of materials and to the grades and sections indicated on the plans and in accordance with the applicable construction requirements of

the contract and adequately maintained, consideration will be given under the conditions and provisions of Subsection 107.17.

The Contractor shall maintain the surface of the existing facility and connections thereto on which the Contractor is required to maintain traffic. Such maintenance shall be in accordance with the provisions of Subsections 104.04 and 105.14 and other applicable requirements and shall be subject to the provisions of Subsection 105.15. All costs for such maintenance and surface repairs shall be included in the contract price bid for Maintenance of Traffic. Repair of structural failures in the pavement foundation, or a structure beneath the surface not resulting from the Contractor's failure to comply with the requirements or limitations of the contract, or from the Contractor's operations, will be the responsibility of the Department. The Department may, however, at its discretion require the Contractor to make repairs and will pay for them at the contract unit prices for the items and quantities of work involved or as Extra Work.

**618.04--Method of Measurement.** This work will be measured as a unit lump sum quantity consisting of continuous maintenance and protective services. The percentages of the contract lump sum price allowed on progress estimates will be determined by the percentage of the combined total monetary value of all direct bid items, excluding those items identified in the bid schedule as dependent items, earned during the current (same) estimate period. However, when the construction and traffic control signs have been erected the Contractor will be allowed payment at least equal to the value of the signs as computed at the fixed price for additional construction signs included in the contract.

For contracts containing pay items for individual traffic control devices, measurement of these items will be in accordance with Subsection 619.04.

In the event the Engineer determines that actual field and traffic conditions require fixed-in-place signs in addition to those shown on the line diagram of the plans, they shall be furnished, erected, and maintained, and measurement of these signs will be made by the square foot.

Construction and removal of detour bridges will be measured as a lump sum quantity, consisting of furnishing all labor and materials, construction, repair and replacement as deemed necessary during the life of the project and removal as follows:

After the permanent bridge is opened to traffic, the detour bridge shall be removed. All Contractor furnished material shall remain the property of the Contractor and shall be removed from the site.

Percentages for construction and removal of each detour bridge commensurate with the magnitude of the work will be applied as follows:

Construction of Detour Bridge .....	80%
Removal of Detour Bridge .....	20%

Each month the Engineer will estimate the percentage of construction and removal of each detour bridge and apply the percentage as indicated herein.

**618.05--Basis of Payment.** Maintenance of traffic, will be paid for at the contract lump sum price which will also include compensation for complying with the requirements of the Traffic Control Plan.

Individual traffic control devices that are included in the contract as pay items will be paid for in accordance with Subsection 619.05.

For contracts not containing pay items for individual traffic control devices, additional construction signs ordered by the Engineer will be paid for at the fixed contract unit price indicated in the bid schedule.

Construction and removal of detour bridges, measured as provided in Subsection 618.04, will be paid for at the contract lump sum bid price bid, which price shall be full compensation for furnishing all labor and materials, construction, repair, replacement and removal when ordered by the Engineer.

Additional maintenance responsibilities covering maintenance of the embankment, base and paving on detour roads will be measured and paid for as set out in Section 618.

These prices shall be full compensation for completing the work.

Payment will be made under:

- 618-A: Maintenance of Traffic - lump sum
- 618-B: Additional Construction Signs - per square foot
- 618-C: Construction and Removal of Detour Bridge - lump sum

**SECTION 619 - TRAFFIC CONTROL FOR CONSTRUCTION ZONES**

**619.01--Description.** This work consists of furnishing, placing, maintaining or replacing as necessary, removing when no longer applicable and installation at other locations all traffic control devices including pavement marking materials (paint, tape, markers, etc.) in accordance with contract provisions and as directed by the Engineer.

**619.02--Materials.** Certification of traffic control devices shall be in accordance with the provisions of Subsection 619.02.13.

**619.02.1--Painted Traffic Stripe.** Painted traffic stripe shall meet the applicable requirements of Sections 710 and 720.

**619.02.2--Pavement Marking Tape.** Preformed pavement marking materials must be listed on the Department's "Approved Sources of Materials" and meet the requirements of Subsection 720.05.

**619.02.3--Reflective Raised Pavement Markers.** Raised pavement markers must be on the Department's "Approved Sources of Materials" and shall meet the applicable requirements of Subsection 720.03.

**619.02.4--Construction Signs.** Construction signs shall meet the applicable requirements of Sections 618 and 721 and the following:

Sign supports may be steel beams, structural steel pipe, steel U-section posts, 4-inch x 4-inch wood posts, portable easels, or barricades as required for installation. Breakaway bases shall be provided for all steel beams and pipe posts. Portable sign supports may be used for daylight operations, moving work areas, or other short-term activities. Standards for height of construction signs shall be those shown for roadside signs in Chapter 6F of the Manual of Uniform Traffic Control Devices (MUTCD). Signs mounted on portable supports or barricades may be at lower heights but the bottom of the sign shall be no less than one foot above the traveled way.

Unless specified otherwise, fluorescent orange reflective sheeting, meeting the requirements of Subsection 721.06, shall be used on all construction signs regardless of whether used during daytime or nighttime hours.

Unless otherwise specified on the plans, the material on which the reflective sheeting is to be applied shall be as a minimum, 16-gauge steel, 0.080-inch aluminum, or 5/8-inch high density overlaid plywood. Ungalvanized steel, exterior grade plywood and lumber shall have a minimum of two coats of paint on front, back, and edges. High density overlaid plywood shall have the edges painted. The material to which reflective sheeting is to be applied shall be prepared in accordance with the recommendations of the sheeting manufacturer.

For new signs, the Contractor shall furnish the Engineer with three certified copies of a statement or test report from the producer indicating that the signs meet the requirements of the specifications.

Previously used signs will be accepted on the basis of reflectivity and legibility. Reflectivity for these signs may be tested by the Engineer in accordance with the procedures set out below or by the Central Laboratory in Jackson. If tested by the Central Laboratory, the reflective sheeting shall have at least 50 percent of the reflectivity specified for new sheeting. Tests performed in the Central Laboratory will be for reflectance only, and the Contractor shall pay the testing



charges. Legibility in all cases will be determined by the Engineer.

The determination for reflectivity and legibility by the Engineer will be made from the drivers seat of an automobile with the headlamps on low beam between the hours of one hour after sunset and one hour before sunrise at the distance specified below. The signs shall be mounted at the specified height for each type sign as it is being tested. Should the Contractor elect to have the signs tested in place, each sign not meeting the requirements of these specifications shall be immediately removed and replaced. The Engineer will certify by letter to the State Materials Engineer that the signs have been tested and accepted under this procedure.

A sign will be considered as meeting the reflectivity requirements of this specification when the shape and color of the sign can be unquestionably identified at a distance of 1500 feet from the sign. In cases where grade or alignment will not permit a sight distance of 1500 feet, the distance for specification compliance shall be the furthestmost point at which the complete sign becomes visible.

If there is a question as to a sign being acceptable, the sign may be sent to the Central Laboratory for verification. Testing charges will be borne by the State when the verification test determines that the sign is acceptable.

Legibility will be acceptable when the sign letters and numerals are capable of being read at a distance determined by the following formula:

$$D = 50 H$$

D = Distance in Feet

H = Letter/numeral height in inches

**619.02.5--Advance Warning Flashing Arrow Panels.** Flashing arrow panels shall meet the requirements of Section 6F.53 of the MUTCD.

**619.02.6--Median Barrier and Delineators.** Precast concrete median barrier shall meet the requirements of the plans, contract documents, and Section 615 except the surface may be a Class 1 ordinary surface finish unless designated otherwise. When precast concrete median barriers are no longer needed at one location, as determined by the Engineer, the barriers shall be removed and reset at other designated locations. When barriers have to be stored until needed at another location, payment for removing and resetting will not be made until they are reset at their designated location. The Contractor shall furnish the storage area.

The Engineer may allow the installation of used barriers for temporary traffic control upon an inspection and determination that the barrier units are structurally adequate for their intended purpose and they meet the requirements

of the Section. Barriers with small chips or fractures not affecting their integrity may be accepted.

Precast concrete barriers used on construction projects which were purchased or manufactured after October 1, 2002 must meet the requirements of NCHRP Report 350. Precast median barriers purchased or manufactured prior to October 1, 2002 may be used until they complete their normal service life.

Certification of precast concrete barriers shall be as required in Subsection 619.02.13.

Portable median barrier shall be a highly portable, crashworthy barrier especially designed and used as a temporary barrier on highway construction projects. The barriers shall be designed so that it can be filled with water when in use and be easily drained for moving and transporting. The barrier shall be National Cooperative Highway Research Program Project (NCHRP) Report 350 approved for the speed rating indicated on the plans or in the contract documents.

The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that the portable median barriers furnished meets the requirements of this Section.

Delineators shall be listed on the Department's "Approved Sources of Materials" and meet the requirements of the plans and Section 6F.68 of the MUTCD.

**619.02.7--Channelization Devices, Barricades, and Warning Lights.** Channelization devices, vertical panels, tubular markers, cones, drums, barricades and temporary raised islands shall meet the requirements of the plans and Sections 6F.55 through 6F.64 of the MUTCD. Drums shall be constructed of lightweight, deformable material capable of retaining reflective sheeting. Reflective sheeting for drums shall be Type III meeting the requirements of Subsection 721.06. Warning lights shall meet the requirements of Section 6F.72 of the MUTCD.

**619.02.8--Traffic Signals and Flashers.** Traffic signals and flashers shall meet the requirements of the plans and Section 6F.71 & 6F.74 of the MUTCD.

**619.02.9--Impact Attenuators.** Impact attenuators must be listed on the Department's "Approved Sources of Materials".

Replacement Packages. Replacement packages shall consist of spare parts of the expected type and number needed to repair one hit for every three attenuators in place.

**619.02.10--Temporary Guardrail.** Temporary guardrail shall meet the requirements of the plans and the applicable requirements of Sections 606 and

712.

**619.02.11--Snap-Back Delineators.** Snap-back delineators shall be selected from the list of surface mounted flexible delineator posts as shown on the Department's "Approved Sources of Materials".

**619.02.12--Terminal End Section.** Terminal end sections, installed as per manufacturer's recommendations, shall be National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 3 (TL-3) approved. When specified in the plans, the terminal end sections shall be the type specified, unless otherwise approved by the Engineer.

The Contractor shall furnish the Project Engineer two (2) copies of the manufacturer's installation instructions prior to beginning guard rail operations.

**619.02.13--Certification of Traffic Control Devices.** The Contractor will be required to certify that the traffic control devices used on the project meets certain requirements. The traffic control devices shall be certified in accordance with the following requires:

Category 1 Traffic Control Devices. Category 1 traffic control devices are defined as low-mass, single-piece traffic cones, tubular markers, single-piece drums, and delineators.

The Contractor shall certify to the Project Engineer by a letter ONLY stating that the Category 1 traffic control devices, furnished and used, either meet the requirements of NCHRP Report 350 or were purchased prior to October 1, 1998.

All documentation supporting the certification is to be kept on file by the Contractor subject to review by the Department at any time. Support documentation shall be kept on file for two years after the completion of the project.

The Contractor may self-certify Category 1 Traffic Control Devices. In order to make the self-certification, the Contractor shall have as a minimum the following support documentation regarding the certification.

1. A title, e.g., "Certification of Crashworthiness";
2. Name and address of vendor making the certification;
3. Unique identification of the certificate such as serial number, with numbered pages and the total number of pages;
4. Description and unambiguous identification of the item tested;
5. Identification of the basis for self-certification process used and to what test level of NCHRP Report 350. This basis as crash test experience with similar devices or years of demonstrably safe operational performance;
6. A signature and title, or an equivalent identification of the person(s)

accepting responsibility for the content of the certification, however produced, and the date of issue;

7. A statement that the certification shall not be reproduced except in full.

All documentation supporting the self-certification is to be kept on file by the Contractor subject to review by the Department at any time. Support documentation shall be kept on file for two years after the completion of the project.

The Contractor's letter to the Project Engineer shall state that all Category 1 traffic control devices, furnished and used, were purchased after October 1, 1998 and met the requirements of NCHRP Report 350, or that the Category 1 traffic control devices, furnished and used, were purchased prior to October 1, 1998.

Category 2 Traffic Control Devices. Category 2 traffic control devices are defined as barricades, intrusion detectors, vertical panel assemblies, portable sign supports, drums with warning lights, and cones with warning lights.

The Contractor shall certify to the Project Engineer by a letter ONLY stating that the Category 2 traffic control devices, furnished and used, either meet the requirements of NCHRP Report 350 or were purchased prior to October 1, 2000. The Contractor's letter shall state that all Category 2 traffic control devices, furnished and used, were purchased after October 1, 2000 and met the requirements of NCHRP Report 350, or that the Category 2 traffic control devices, furnished and used, were purchased prior to October 1, 2000.

Category 3 Traffic Control Devices. Category 3 Traffic Control Devices are items similar to Category 2 but weigh more than 100 pounds. Category 3 Traffic Control Devices include concrete barrier, truck mounted attenuators (TMAs), workzone crash cushions, and fixed sign supports.

Concrete barrier and fixed sign supports, furnished and used, and purchased after October 1, 2002 must meet the requirements of Report 350.

The Contractor shall furnish a letter ONLY certifying that all concrete barrier and fixed sign supports purchased after October 1, 2002 meets the requirements of NCHRP Report 350. Concrete barrier and fixed sign supports purchased prior to October 1, 2002 may be used without written certification until they complete their normal service life.

Work zone crash cushions and truck mounted attenuators (TMAs), furnished and used, and purchased after October 1, 1998 must meet the requirements of Report 350.

The Contractor shall furnish a letter certifying that all work zone crash cushions and TMAs purchased after October 1, 1998 meets the requirements of NCHRP

Report 350. Work zone crash cushions and TMAs purchased prior to October 1, 1998 may be used without written certification until they complete their normal service life.

Contractor's Letter to the Project Engineer. The following is an example of a letter to the Project Engineer.

*"I, (Contractor's name), certify that the Category 1 traffic control devices used on this project and purchased after October 1, 1998 meet the requirements of NCHRP Report 350 and all Category 1 traffic control devices used on this project not meeting NCHRP Report 350 were purchased prior to October 1, 1998.*

*I also certify that the Category 2 traffic control devices used on this project and purchased after October 1, 2000 meet the requirements on NCHRP Report 350 and all Category 2 traffic control devices used on this project not meeting NCHRP Report 350 were purchased prior to October 1, 2000.*

*I also certify that except for concrete median barrier, all of the Category 3 traffic control devices crash cushions and truck mounted attenuators used on this project and purchased after October 1, 1998 meet the requirements on NCHRP Report 350 and all Category 3 crash cushions and truck mounted attenuators used on this project not meeting NCHRP Report 350 were purchased prior to October 1, 1998."*

### **619.03--Construction Requirements.**

**619.03.1--General.** Traffic control devices shall be furnished and utilized in accordance with the Traffic Control Plan (TCP), reference Section 618. Upon failure of the Contractor to adequately maintain traffic control devices and safe movement of traffic through the construction zones, the provisions of Subsection 105.15 will be invoked.

**619.03.2--Temporary Stripe.** Temporary stripes are pavement markings, temporary in nature, such as those used to direct traffic from it's customary path or those to be removed from the pavement course under use for further temporary traffic control or those to be covered by the next pavement course and/or those to be replaced by permanent stripes. Temporary stripes shall be 4-inch paint or preformed tape as designated on the plans or when not designated, the use of paint or tape will be at the Contractor's option. Temporary stripes on surface treatments shall be paint.

All temporary stripe shall be placed in accordance with the plans and the requirements set out in Section 625, except that alignment of temporary stripe placed on underlying courses shall have a tolerance of four inches in fifty (50) feet from true alignment for skip stripes and edge lines and one inch in fifty (50)

feet from true alignment for no-passing stripes and lane lines. When preformed tape is used on the final pavement course for temporary traffic markings, it shall be removed at no additional cost to the State.

Temporary paint stripe requiring removal shall be removed by carefully controlled blast cleaning, approved grinding or other approved methods in such a manner that the surface to which the stripe was applied will not be unnecessarily marred or damaged. Preformed tape is to be removed in accordance with the manufacturer's recommendations.

Temporary paint stripe which has been placed on the final pavement course may be left in place and covered with permanent stripe of the same color provided the temporary stripe has been satisfactorily placed in the proper location. Under this condition, any remaining temporary paint stripe not covered by the permanent stripe shall be removed at no additional cost to the State.

Painted traffic stripe which has been removed from the final asphalt pavement surface shall be sealed with an approved sealant. The Engineer may wave the sealant requirement when the area to be sealed is insignificant. This sealing operation shall be performed at no additional costs to the State.

All temporary pavement markings placed and measured for payment under this section shall include any required removal. Removal of all temporary stripe will not be measured for separate payment.

Existing pavement markings conflicting with temporary markings shall be removed. Removal of such materials (paint, tape, marker, etc.) will be measured and payment made under Section 202. When measuring removal of pavement markings for payment, the skips will not be included in the measurement.

### **619.03.3--Blank.**

**619.03.4--Reflective Pavement Markers.** Reflective pavement markers for construction zones shall be secured to the pavement by an approved adhesive. The portion of the highway surface to which the marker is to be bonded shall be free of dirt, grease, oil, moisture, loose or unsound layers and any other material which would adversely affect the bond of the adhesive. Clean pavement need not be blast-cleaned unless the surface contains an abnormal amount of asphalt or the surface is contaminated with dirt, grease, oil, or any other material that would adversely affect the bond of the adhesive. Necessary cleaning shall be performed by blast cleaning.

When a pressure-sensitive pad is used, a primer shall be applied directly to the road surface with a brush or sprayer but is not to be applied when the ambient temperature is lower than 50°F. No marker shall be installed when the relative humidity of the air is greater than 80 percent or when the pavement is not surface

dry. Traffic shall not be permitted to run over the primed area until after the markers have been installed. After priming, allow one minute for the primer to dry, then peel the release paper from the pressure-sensitive pad and immediately place the marker in the correct position on the primed road surface and apply light pressure. Drive slowly over the located marker with one wheel of a truck to help set it in place. Traffic may be allowed immediately.

All markers shall be installed in a uniform line, with controls established by the Engineer. The Engineer will establish controls for each line of markers by setting control points at not less than approximately 600-foot intervals on tangents and 50-foot intervals in curves. All additional work necessary to establish intermediate control points and individual marker points shall be performed by the Contractor. On curves, the line of markers on lane lines and edge lines shall follow the normal curvature of the curve and placement on chords or other variations from the normal curvature will not be permitted, unless specifically shown on the plans or ordered by the Engineer.

Reflective markers shall be installed in such a manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. No markers shall be installed over longitudinal or transverse joints of the pavement surface.

All markers placed out of alignment shall be removed and replaced by a new marker.

**619.03.5--Impact Attenuators.** Impact attenuators shall be installed and maintained by experienced workmen familiar with the installation of impact attenuators. Installation shall be in accordance with the recommendations of the manufacturer. Each impact attenuator shall also include one replacement package. A replacement package shall consist of the quantity of materials necessary to repair one hit for every three attenuators in place. The Contractor shall use these parts to maintain the attenuator during the construction period. When it becomes necessary to install a replacement package, the Contractor shall order an additional replacement package to have available for future use. All unused parts and the attenuators shall become the property of the Contractor upon completion of the project.

**619.03.6--Temporary Guardrail.** Temporary guardrail shall be installed in accordance with the plans and the applicable provisions of Section 606.

The sites where temporary guardrail has been removed shall be restored to their original condition or to an improved condition if part of the contract.

Salvage of temporary guardrail designated to become the property of the Department shall be in accordance with Subsection 202.03.

**619.03.7--Maintenance of Traffic Signs.** All signs whether placed new or previously used shall meet the requirements of this specification on each inspection. Signs failing to comply with these requirements shall be replaced at no additional cost to the State.

**619.03.8--Snap-Back Delineators.** Snap-back delineators shall be installed in accordance with the manufacturer's recommendations and at the locations shown on the plans or directed by the Engineer. Delineators that are damaged by traffic to the extent that they are non-functional shall be replaced as quickly as possible.

**619.03.9--Portable Median Barrier.** Portable median barriers shall be installed in accordance with the manufacturer's recommendations. The barriers shall be installed at the locations shown on the plans, or as directed by the Engineer.

**619.04--Method of Measurement.** Traffic control devices will be measured one time only by the units indicated and when moved from the original location to other locations as required by the contract or as directed by the Engineer will not be measured for additional payment except when the contract includes the pay item, "Remove and Reset." The total pay quantity for each traffic control device excluding traffic stripe shall not exceed the maximum number of installations in place at any given time during the life of the contract. Unless otherwise provided for, replacement of devices will not be measured for payment.

The unit price for each type and color of detail striping shall be based on striping a width of six inches. When striping of a width greater than six inches is specified in the contract, or ordered, the measured length of striping will be converted to an equivalent length of six-inch width.

Temporary stripe, completed and removed in accordance with the requirements of this Section, will be measured by the mile or by the linear foot, as indicated, from end-to-end of individual stripes. In the case of skip lines the measurement will include skips. The length used to measure centerline, lane lines and edge stripes will be the horizontal length computed along the stationed control line. Detail traffic stripe will be measured by the linear foot from end-to-end of individual stripes. Measurement will be made along the surface of each stripe and will exclude nominal skip intervals where specified. Stripes more than four inches in width will be converted to equivalent lengths of four-inch stripe.

Legend, which is to include railroad markings, pedestrian crosswalks and stop lines, will be measured by the square foot or linear foot. Pay areas of individual letters and symbols will usually be shown on the plans and measured by the square foot. Transverse railroad bands, pedestrian crosswalks and stop lines will generally be measured by the linear foot, in which case, stripes more than four inches in width will be converted to equivalent lengths of four-inch widths.

Each impact attenuator installation, including one replacement package, will be



measured by the unit for each installation as shown on the plans. Replacement packages, excluding the package included with the initial attenuator, will be measured by the unit in accordance with these specifications.

Initial snap-back delineators will be measured by the unit. Replacement will be measured as follows:

- (a) Replace reflective material measured as 1/4 unit.
- (b) Replace complete tube measured as 1/3 unit.
- (c) Replace shock cord adapter measured as 1/3 unit.

**619.05--Basis of Payment.** Traffic control devices will be paid for at the contract unit price for the units specified. Devices that have been measured for payment and subsequently require repair or replacement will be dropped from payment on future estimates unless satisfactorily repaired or replaced.

Payment for devices for which no pay items are contained in the contract will be included in the unit prices of contract items and/or in the lump sum contract price for Maintenance of Traffic.

The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

619-A1:	Temporary Traffic Stripe, Continuous White, <u>Description *</u>	- per linear foot or mile
619-A2:	Temporary Traffic Stripe, Continuous Yellow, <u>Description *</u>	- per linear foot or mile
619-A3:	Temporary Traffic Stripe, Skip White, <u>Description*</u>	- per linear foot or mile
619-A4:	Temporary Traffic Stripe, Skip Yellow, <u>Description*</u>	- per linear foot or mile
619-A5:	Temporary Traffic Stripe, Detail, <u>Description*</u>	- per linear foot
619-A6:	Temporary Traffic Stripe, Legend, <u>Description*</u>	- per square foot or linear foot
619-B:	Blank	
619-C1:	Red-Clear Reflective Raised Pavement Marker	- per each
619-C2:	Two-Way Yellow Reflective Raised Pavement Marker	- per each

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619-C3: One-Way Clear Reflective Raised Pavement Marker	- per each
619-C4: One-Way Yellow Reflective Raised Pavement Marker	- per each
619-C5: Yellow Clear Reflective Raised Pavement Marker	- per each
619-C6: Red-Clear Reflective High Performance Raised Marker	- per each
619-C7: Two-Way Yellow Reflective High Performance Raised Marker	- per each
619-C8: One-Way Clear Reflective High Performance Raised Marker	- per each
619-C9: One-Way Yellow Reflective High Performance Raised Marker	- per each
619-C10: Yellow Clear Reflective High Performance Raised Marker	- per each
619-D1: Standard Roadside Construction Signs, Less than 10 Square Feet	- per square foot
619-D2: Standard Roadside Construction Signs, 10 Square Feet or More	- per square foot
619-D3: Remove and Reset Signs, All Sizes	- per each
619-D4: Directional Signs	- per square foot
619-D5: Directional Signs, Overhead, <u>Location</u>	- lump sum
619-E1: Flashing Arrow Panel, Type _____	- per each
619-E2: Sequencing Chevron Panel, <u>Size</u>	- per each
619-F1: <u>**</u> Median Barrier, <u>***</u>	- per linear foot
619-F2: Remove and Reset <u>**</u> Median Barrier, <u>***</u>	- per linear foot
619-F3: Delineators, <u>Mounting</u> , <u>Description</u>	- per each
619-F4: Snap-Back Delineator	- per unit
619-F5: Snap-Back Delineator, Replacement	- per unit
619-G1: Blank	

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619-G2: Barricades, Type I	- per each
619-G3: Barricades, Type II	- per each
619-G4: Barricades, Type III, ****	- per linear foot
619-G5: Free Standing Plastic Drums	- per each
619-G6: Warning Lights, Type A	- per each
619-G7: Warning Lights, Type B	- per each
619-G8: Warning Lights, Type C	- per each
619-H1: Traffic Signals, <u>Location</u>	- lump sum
619-H2: Hazard Identification Beacons	- lump sum
619-J1: Impact Attenuator, <u>Speed Rating</u>	- per unit
619-J2: Impact Attenuator, <u>Speed Rating</u> , Replacement Package	- per unit
619-K1: Installation and Removal of Guardrail, Type____, Class____	- per linear foot
619-K2: Installation and Removal of Guardrail, Type____ Bridge End Section	- per each
619-K3: Installation and Removal of Guardrail, Type____ Cable Anchorage	- per each
619-K4: Installation and Removal of Guardrail, Terminal End Section	- per each

\* The description for temporary traffic stripe will be shown as "paint" or "tape". In the case of "tape" the type will also be designated. When the description is not designated, the use of "paint" or "tape" will be at the Contractor's option.

\*\* Indicate Concrete or Portable

\*\*\* Indicate Speed Rating, Color, etc. if applicable

\*\*\*\* Indicate if barricade is to remain with "Permanent"

## SECTION 620 - MOBILIZATION AND REQUISITE WORK

**620.01--Description.** Mobilization consists of moving all labor, equipment,

supplies, and incidentals to the project site and removing same after other work under the contract has been completed. It also includes all mobilization pre-construction costs which are necessary direct costs to the project and are of a general nature rather than directly attributable to other pay items.

Requisite work consists of the preparation for and the performance of construction necessary as a requisite to the performance of other items of work and the cost of such work when no other provisions are made in the contract for payment therefore. Such work shall include, but is not limited to, all obligations, preparation, construction and all other costs of requisite work for which no compensation is provided in other items of work.

**620.02--Blank.**

**620.03--Blank.**

**620.04--Method of Measurement.**

**620.04.1--Mobilization.** Measurement for payment will be in accordance with the following schedule:

- (a) When one percent of the original contract amount is earned from other bid items exclusive of those listed as dependent items, 10 percent of the amount bid for mobilization, or one percent of the original contract amount, whichever is lesser, will be paid.
- (b) When five percent of the original contract amount is earned from other bid items exclusive of those listed as dependent items, 50 percent of the amount bid for mobilization, or five percent of the original contract amount, whichever is lesser, will be paid.
- (c) When 10 percent of the original contract amount is earned from other bid items exclusive of those listed as dependent items, 100 percent of the amount bid for mobilization, or 10 percent of the original contract amount, whichever is lesser, will be paid.
- (d) Upon completion of all work, payment of any amount bid for mobilization in excess of 10% of the original contract amount will be paid.

In the event the contract is terminated under the provisions of Subsection 108.09, the percentages listed will not be used in computing total payment, but the percentage of original contract amount, exclusive of dependent items, earned at the time of termination will be applied to the lump sum price bid for mobilization.

**620.04.2--Requisite Work.** For monthly estimates, the Engineer will estimate the percentage of requisite work completed. Upon satisfactory completion of all requisite work, measurement will be considered as 100 percent.

**620.05--Basis of Payment.** Mobilization and requisite work will be paid for at the contract lump sum prices, which shall be full compensation for completing the work. When not listed as pay items, the cost of this work shall be included in the prices for other items bid.

Payment will be made under:

620-A: Mobilization - lump sum

620-B: Requisite Work - lump sum

## **SECTION 621 - FIELD LABORATORY**

**621.01--Description.** When required in the contract, this work consists of providing, for the exclusive use of the Engineer, one or more approved field laboratory buildings or portable trailers in which to house the equipment necessary to conduct required tests. It shall also include the furnishing of utilities as herein provided and the removal of the facilities after the work has been completed. Unless otherwise specified, the building or trailer will remain the property of the Contractor.

**621.02--Blank.**

**621.03--Construction Requirements.** Unless otherwise indicated in the contract, each field laboratory shall be at least seven and one-half feet wide, seven feet high inside, and shall contain at least 150 square feet of floor space. Each unit shall be floored, roofed, and weather-tight and shall contain the following:

- (a) At least three windows, each having at least six and one-half square feet of opening.
- (b) At least one door with lock and two keys.
- (c) A suitable work bench with adequate drawers.
- (d) Sink with running water supply as necessary for running tests.
- (e) Adequate ventilation and lighting, and facilities for providing reasonable temperature control.
- (f) Adequate supply of gas and electric current as required for testing.

In addition to the above, the Contractor shall provide toilet facilities within one

hundred feet of each field laboratory.

Each unit shall be located as specified, and in the case of central mixing or other plants, the unit shall be so located that the details of the Contractor's or producer's plant operations are in plain view of and visible from at least one window. Where the Contractor's operations are such that the Engineer deems it advisable to do so, the Contractor shall move the unit to other suitable location(s). The Engineer shall be the sole judge as to the number of laboratory units required.

**621.04--Method of Measurement.** Each specified field laboratory conforming to the requirements of the contract will be measured by the unit complete in place.

**621.05--Basis of Payment.** Field laboratories furnished as specified will be paid for at the contract unit price per each, which price shall be full compensation for all materials, equipment, tools, labor, utilities, and incidentals necessary to provide each unit, for moving the unit(s) to other suitable locations, and for removal from the work before final acceptance.

Payment will be made under:

621-A: Field Laboratory - per each

621-B: Field Laboratory, Per Plans - per each

**SECTION 622 -- ENGINEER'S FIELD OFFICE BUILDING**

**622.01--Description.** When required in the contract, this work shall consist of furnishing and maintaining a field office building for the exclusive use by the Engineer. The field office shall consist of a building, house, mobile office or trailer, approved by the Engineer, and in reasonably close conformity with these specifications.

When so indicated in the contract by pay item designation: LO (Laboratory and Office Building) this work shall also consist of the furnishing and maintaining of a combination field laboratory and field office building in reasonably close conformity with the requirements of these specifications.

In all cases where not specifically provided otherwise, this work shall also consist of furnishing appliances and utilities as herein provided, and the removal of the facilities after the work has been completed; it being understood that the building or trailer remains the property of the Contractor furnishing such facility.

**622.02--Materials.** All materials and appurtenances required shall be of good commercial quality, approved by the Engineer; however, sampling and testing

will not be required.

**622.03--Construction Requirements.**

**622.03.1--Types of Field Office Buildings.** Field office buildings shall be designated as Type 1, Type 2 or Type 3. Combination field laboratory and field office buildings shall be designated as Type 2 LO, or Type 3 LO.

**622.03.1.1--Type 1, Type 2 and Type 3 Field Office Buildings.** Type 1, Type 2 or Type 3 Field Office Buildings shall meet the following minimum requirements:

A. Dimensions. All measurements shown are clear inside dimensions as follows:

Building	Constructed on or for Project linear feet, minimum			Commercially Produced linear feet, minimum		
	Width	Length	Head-Room	Width	Length	Head-Room
Type 1	8.0	10.0	8.0	7.5	9.5	7.0
Type 2	10.0	30.0	8.0	9.5	29.5	7.0
Type 3	12.0	50.0	8.0	11.5	49.5	7.0

B. Doors and Windows.

1. Each building shall be provided with at least one standard height solid entrance door complete with lock and at least two keys. The opening shall also be provided with a self closing screen door. Type 3 Building shall have at least two such doors and screens.
2. Each wall, unless predominately occupied by a door shall be provided with at least one hinged, jalousied, or sliding window; glazed, screened and fitted with venetian blinds. Each window shall have an area of at least 6.5 square feet of opening, except toilet area which may be 3.25 square feet.

Type 1 Building shall have at least three windows.

Type 2 Building, at least six windows.

Type 3 Building, at least 10 windows.

C. Walls and Roof. If constructed on or for the project, walls and roof of all types shall be constructed with 2 x 4 studs and rafters.

1. Both sides of walls shall be covered with 3/8-inch thick plywood; exterior grade on the outside. No open cracks or knotholes will be

permitted. If commercially produced, standard wall construction will be accepted.

2. Roof: The roof shall be water tight and shall slope at least one inch in twelve inches (1:12) in one direction away from the door if practicable. It shall have at least 12-inch eaves. If commercially produced, an arched roof without eaves will be accepted.
3. At least 1¼-inch thick rock wool, fiber glass or other non-flammable insulating material shall be placed in the walls and ceiling. This material shall be in all wall and ceiling cavities not occupied by a door or window.

D. Ceiling. The ceiling on all types shall be covered on the inside of the roof rafters with 3/8" minimum thickness plywood if constructed on the project. Standard ceiling will be accepted if commercially produced.

E. Floor. The floor may be timber, a minimum of 12 inches above the ground on 2 x 6 joists. Open cracks, open knotholes, etc. will not be permitted.

F. Heater. The heater may be oil fired, gas or electric. Oil and gas units shall be properly vented to the outside, provided with adequate outside fuel storage and shall be connected thereto with suitable feed lines. Gas units may be connected to a commercial gas main, if available. The heater shall be capable of furnishing sufficient heat to maintain an inside temperature of 72 to 78°F.

G. Work Table, Desk, Chairs, Filing Cabinet, Plan Rack and Locker. Work tables shall be provided, with the tops measuring at least 3' 0" x 7' 6"; shall be stable and constructed with 3/4-inch plywood covered on top with smooth masonite. The height shall be approximately 3' 0" above the floor. One such table shall be provided for a Type 1 Building, 2 or more for a Type 2 Building, and 3 or more for a Type 3 Building. At the option of the Contractor, portable engineers' drafting tables of comparable size may be provided in lieu of the tables indicated hereinabove.

For Type 3 Buildings the Contractor shall also furnish one 30-inch x 60-inch minimum size office desk and swivel chair plus two straight chairs and shall also furnish a metal four-drawer vertical filing cabinet, one plan holder rack, one approved locker with separate lock and key for storing Engineer's instruments, two clothes lockers or closets, and one fire extinguisher.

H. Stools. Two stools of the proper height shall be furnished for each work site.

I. Miscellaneous Storage Shelves. Except for Type 3 buildings, six linear feet of storage shelves for books, etc., shall be furnished. If two 3-foot shelves are furnished, they shall be no less than 12 inches apart vertically. Type 3 Buildings



shall have six linear feet of shelves in each end.

J. Toilet Facilities. Type 2 and Type 3 Buildings shall have satisfactory indoor enclosed toilet facilities meeting the sanitary code of the local governmental agency having jurisdiction in the area where the unit is to be used. For Type 1 Buildings, the Contractor shall provide at the site of the building outdoor toilet facilities meeting the applicable sanitary code.

K. Utilities. All utilities, including water, sewage, gas and electricity, shall be connected to their service source ready for use prior to the Engineer's occupancy.

Water service shall be potable quality or a separate drinking water supply shall be furnished. Lighting shall be adequate to provide not less than 70-foot candles of light on all working surfaces. Not less than one electrical convenience outlet shall be provided for each desk and table plus two additional outlets each in the office space and laboratory space. Heating and cooling shall be thermostatically controlled. The Contractor shall have one telephone installed in the name of the Engineer.

The telephone service shall be capable of providing service to the Project Office, District Office, Contractor's Field or Main Office, and the Central Offices in Jackson.

The Contractor shall provide an all weather access road to the field office and laboratory and parking for not less than six full-sized automobiles.

For the duration of the contract, the Contractor shall maintain the field office and laboratory, shall provide janitor service at least once each week, and shall supply all heating fuel, electricity, water, and telephone service.

L. Air Conditioner. For Type 2 and Type 3 Buildings, an air conditioning unit shall be furnished and shall be capable of furnishing sufficient cooling to adequately maintain an inside temperature of 72 to 78°F.

**622.03.1.2--Type 2 LO and Type 3 LO Field Office Buildings.** Type 2 LO or Type 3 LO buildings shall meet the requirements specified hereinabove for Type 2 or Type 3, respectively, and in addition shall meet the following minimum requirements:

A. Dimensions. Type 2 LO buildings shall have dimensions not less than those specified for Type 2 above and, in addition, shall be partitioned into two rooms. One room for laboratory space shall consist of not less than 125 square feet floor space, shall consist of not less than 150 square feet floor space, including toilet, with the combined total floor space of not less than that specified for Type 2 above. Each Type 2 LO building shall have two entrance doors as described in Subsection 622.03.1.1, B, 1.

Type 3 LO Buildings shall have dimensions not less than those specified for Type 3 above, and, in addition, shall be partitioned into two rooms. One room for laboratory space shall consist of not less than 150 square feet of floor space and other room for office space shall consist of not less than 400 square feet of floor space, including toilet, with the combined total floor space of not less than that specified for Type 3 above.

Each LO building shall have a swinging or sliding door between the specified two rooms.

B. Construction and Facilities. Type 2 LO or Type 3 LO buildings shall be constructed, equipped and utilities provided as set out in Subsection 622.03.1.1, B through L, except that the portion indicated to be used as a field laboratory shall be modified to provide minimum laboratory facilities as specified in Subsection 621.03.

Heating and cooling facilities shall be such as to provide the temperatures specified in Subsection 622.03.1.1, F and L, in each room.

The Contractor may furnish larger buildings than the type specified, provided all inside arrangements meet minimum requirements and are approved by the Engineer.

When a Type 2 LO or Type 3 LO building is specified, the Contractor may furnish either a single building partitioned as indicated to provide the required space, or separate units, one in accordance with the construction details of Section 621 and the other in accordance with this Section 622 for Type 2 or Type 3, depending upon whether Type 2 LO or Type 3 LO is specified.

In case separate units are furnished, each shall be equipped, located and services provided as if each were specified.

**622.03.2--Location.** Engineer's field office building Type 1 shall be located within or near the project limits as directed by the Engineer. As the work progresses the offices shall be moved to other locations at the direction of the Engineer.

Types 2 and 3 office buildings and Types 2 and 3 LO buildings may be located within the project limits or near the project as directed by the Engineer. Whenever possible the building shall be located within 1,000 feet of a source of electric power provided by the Contractor and the Contractor shall provide such electric power to the building as indicated hereinabove. When the Engineer determines it is necessary to so locate the building that electric power must be transmitted for exclusive use by the Engineer for a distance in excess of 1,000 feet, the cost for that part of the distance in excess of 1,000 feet shall be

considered Extra Work.

**622.03.3--Ownership and Use.** Whether owned, leased or rented by the Contractor, possession of each building will remain with the Contractor who provides the building. The building(s) and all appurtenances shall be furnished, located and made ready for use by the Engineer as a first item of work. The building(s) shall be reserved for the exclusive use of the Engineering Personnel for such time as considered necessary, but no longer than the date of final release from maintenance on the project. The use, location, relocation and removal shall be under the direction and control of the Engineer and no portion of the building shall be occupied, or otherwise used by the Contractor, unless permitted by the Engineer in writing and subject to any provisions or limitations set forth in such written permission. When no longer needed, and upon specific instructions of the Engineer, each building shall be removed from the project.

**622.04--Method of Measurement.** Each specified Engineer's field office building conforming to the requirements of the contract and including all facilities and utilities as specified will be measured as a unit lump sum quantity.

When a Type 2 LO or Type 3 LO building is specified and the Contractor furnishes separate units as provided in Subsection 622.03.1.2, B, no additional measurement will be made because of the separate units but will be made as if the specified single unit had been furnished.

**622.05--Basis of Payment.** The Engineer's field office buildings or combination field laboratory and office building furnished as specified and measured as prescribed above will be paid for at the contract unit price bid per each, which price shall be full compensation for all materials, design, construction, furnishing, maintaining; for all fuel, water, sewage disposal, telephone service, electricity, including transformer if necessary, moving to and from the project and movements on the project, all as specified or directed by the Engineer as provided in the contract, and for all costs incidental thereto; except when the Engineer determines that the necessary location of the building is such that electrical current must be carried for the exclusive use of the Engineer for a distance in excess of 1,000 feet from its source, the cost of furnishing service lines in excess of 1,000 feet will be paid for as Extra Work.

Payment for each Engineer's field office building or LO building provided in accordance with the contract will be made in two installments. Sixty-five (65) percent of the contract price bid will be paid on the first monthly estimate after occupancy by the Engineer and the remaining thirty-five (35) percent will be paid when the use of the building has been concluded by the Engineer as provided herein.

Payment will be made under:

Section 622

622-A: Engineer's Field Office Building, Type \_\_\_\_

622-B: Engineer's Field Office Building, Type \_\_\_\_ LO

Section 622

- per each

- per each

## SECTION 625 - PAINTED TRAFFIC MARKINGS

**625.01--Description.** This work consists of furnishing materials and applying reflectorized painted traffic markings in reasonably close conformity with these specifications and the details shown on the plans or established.

**625.02--Materials.** Paint shall be the color specified and shall meet the applicable requirements of Section 710.

Application of permanent painted traffic markings shall require Class B (High-Visibility) glass beads; otherwise, Class A (Standard) glass beads shall be required. Glass beads shall meet the requirements of Subsection 720.01.

### **625.03--Construction Requirements.**

**625.03.1--Equipment.** All paint shall be applied by approved mechanical equipment providing constant agitation of paint, traveling at controlled speeds, with one or more paint "guns" synchronized to begin and cut off paint flow automatically for skip lines, and subject to manual control for continuous lines of varying length. The machine, or a separate machine, shall be equipped with a glass bead dispenser adjusted and so synchronized with the paint applicator as to distribute the beads uniformly on the painted lines within 10 seconds. Calibration charts and devices for measurement of tanks shall be provided by the Contractor for determining the quantity being applied.

All painting equipment and operations shall be under the control of an experienced technician thoroughly familiar with the equipment, materials, and marking layouts.

**625.03.2--Preparation of Surface.** All areas to be painted shall be thoroughly cleaned. Cleaning may be done by hand brooms, rotary brooms, air blast, scrapers, or whatever combination of equipment is necessary to clean the pavement thoroughly without damage to the surface. Before edge striping, particular care shall be taken to remove all vegetation, loose soil, and the like from the area to be painted. Should other methods fail, the surface shall be wetted with a water jet and scrubbed as necessary to dislodge all foreign material. After washing, the surface shall be allowed to dry thoroughly, and all films of dried mud apparent after surface drying shall be removed before application of paint. Painting shall follow as closely as practicable after the surface has been cleaned and dried, but no paint shall be applied until the surface has been inspected and permission given to proceed. The cost for preparing the surface shall be included in the unit prices for the marking items.

Upon request, the Engineer will establish control points for markings, by type and color, at necessary intervals not to exceed 600 feet. The Contractor shall

preserve and apply markings in conformity with control points established.

**625.03.3--Application.** The paint shall be applied when the ambient temperature is no less than 50°F, the pavement surface is properly prepared and the temperature of the pavement surface is no less than 50°F.

For four-inch temporary traffic stripe, paint and Class A glass beads shall be uniformly applied at the rate of not less than one gallon of paint and six pounds of beads per 264 linear feet of four-inch stripe. For six-inch permanent traffic stripe, paint and Class B glass beads shall be uniformly applied at the rate of not less than one gallon of paint and twelve pounds of beads per 176 linear feet of six-inch stripe.

The length and width of lines shall be within a tolerance of plus or minus three inches and plus or minus 1/8 inch, respectively. For skip markings, the tolerance for intervals shall not exceed the line length tolerance.

Markings applied at less than minimum material rates, deviating from true alignment by more than one inch in 50 feet, exceeding stipulated length and width tolerances, and showing light spots, faulty distribution of beads, smears, or other deficiencies or irregularities shall be removed and replaced. Removal methods shall be in accordance with Subsection 619.03.2.

**625.03.4--Protection.** The newly painted markings shall be protected so that, insofar as possible, paint will not be picked up by the tires of passing vehicles. Warning signs shall be placed at the beginning of a wet line and at points well in advance of the marking equipment. For the benefit of the Contractor, small flags or other similarly effective small objects may be placed near freshly applied lines at frequent intervals to reduce crossings by traffic. Damaged portions of stripes shall be effaced and replaced by the Contractor at no additional cost to the State.

Operations shall be conducted so that traffic can move without undue hindrance. When public traffic is being maintained, warning signs at the starting end shall be moved forward as sections of stripe dry sufficiently to prevent pick-up under traffic. Reference is made to Subsection 710.02.2.2 for the particular paint involved.

**625.03.5--Detail Traffic Stripe.** Detail traffic stripe shall be those short stripes, exclusive of lane and edge striping of the main facility, at exit and entrance ramps, turnouts, turn bays, and other locations indicated on the plans. When shown on the plans or directed by the Engineer, detail stripe of the color, width, and length shall be placed in accordance with the provisions and requirements of this section.

**625.03.6--Legend.** Legend shall be applied by the use of templates cut to the dimensions shown on the plans, or by other methods approved by the Engineer

which will provide a clean cut, uniform, and workmanlike appearance. All other requirements for legend shall be in accordance with the applicable materials and construction requirements of this section.

Legend which fails to have a uniform, satisfactory appearance either by day or by night shall be corrected by the Contractor or removed and replaced at no additional cost to the State.

**625.04--Method of Measurement.** Painted traffic markings completed in accordance with the plans and specifications will be measured by the mile or by the linear foot, as indicated, from end-to-end of individual stripes. In the case of skip lines the measurement will include skips. The length used to measure centerline, lane lines and edge stripes will be the horizontal length computed along the stationed control line.

Detail traffic stripe will be measured by the linear foot from end-to-end of individual stripes. Measurement will be made along the surface of each stripe and will exclude nominal skip intervals where specified. Stripes more than six inches in width will be converted to equivalent lengths of six-inch stripe.

Legend will be measured as provided for legend in 626.04.

**625.05--Basis of Payment.** Painted traffic markings will be paid for at the contract unit price per mile, linear foot, or square foot as applicable.

Restriping of in-place traffic stripe which was not initially placed under the contract will be measured and paid as Traffic Stripe Restriping when the contract includes a bid item for restriping. The restriping will be measured as prescribed above for traffic stripe and will be paid for at the contract unit price which shall be full compensation for preparation of the surface, furnishing and applying all materials, protection of wet paint; and for furnishing all labor, tools, equipment and incidentals necessary to complete the work.

The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

625-A: Traffic Stripe, Skip White	- per linear foot or mile
625-B: Traffic Stripe, Skip Yellow	- per linear foot or mile
625-C: Traffic Stripe, Continuous White	- per linear foot or mile
625-D: Traffic Stripe, Continuous Yellow	- per linear foot or mile
625-E: Detail Traffic Stripe	- per linear foot

625-F: Legend	- per square foot or linear foot
625-G: Traffic Stripe Restriping, Skip	- per linear foot or mile
625-H: Traffic Stripe Restriping, Continuous	- per linear foot or mile
625-I: Traffic Stripe Restriping, Detail	- per linear foot

**SECTION 626 - THERMOPLASTIC TRAFFIC MARKINGS**

**626.01--Description.** This work consists of furnishing materials and placing thermoplastic pavement markings of the type specified in reasonably close conformity with these specifications and the details shown on the plans or established.

Cold plastic traffic markings may be used in lieu of hot applied thermoplastic markings. Substitution will only be allowed for pay items 626-A through H. Substituted cold plastic markings shall be of the same color and width as that required for the hot applied stripe. Unless otherwise specified, the markings, whether hot applied or cold plastic, shall be of the same type material for the entire project. Material and construction requirements for substituted cold plastic traffic markings shall meet the requirements of Section 628 of the Standard Specifications. The layout and spacing for substituted cold plastic traffic markings will remain as shown in the plans, or in the contract documents, for hot applied thermoplastic markings. Measurement of substituted cold plastic traffic markings shall be made in accordance with Section 628 of the Standard Specifications. Payment for substituted cold plastic traffic markings shall be made at the unit price bid for the appropriate hot applied thermoplastic marking.

**626.02--Materials.** The Department reserves the right to perform additional testing of thermoplastic traffic marking materials at any time. Upon request of the State Materials Engineer, samples of the thermoplastic compound, glass beads and epoxy resin shall be furnished.

**626.02.1--Thermoplastic Material.** Thermoplastic material shall meet the requirements of Subsection 720.02, except an alkyd resin shall be used in the formulation when used in construction of stop lines, crosswalks, and legends.

**626.02.2--Glass Beads.** Glass beads shall meet the requirements of Subsection 720.01. Unless otherwise noted, Class A glass beads shall be used.

**626.03--Construction Requirements.**

**626.03.1--Thermoplastic Traffic Stripe.**



**626.03.1.1--Equipment.** Equipment for hot application shall be of sufficient size and stability to insure smooth, uniform, properly aligned markings of the dimensions specified.

The application equipment shall be capable of automatic placement of intermittent and continuous line patterns in single or double line applications simultaneously. The intermittent timer mechanism shall provide a variable ratio of materials applied and variable cycle length such that accurate placement of new patterns, or replacement of existing patterns can be achieved.

The equipment shall also be capable of applying the top dressing of glass beads in a manner which will firmly embed them into the surface of the thermoplastic material for at least one half the diameter of the larger gradation sizes of the beads. The dispensing equipment shall be equipped with an automatic cut-off control for the application of the beads which is synchronized with the cut-off of the thermoplastic material.

**626.03.1.2--Construction Details.** Application of thermoplastic material shall be made only in periods of dry weather and when the temperature of the pavement surface is at least 55°F. The pavement shall be surface dry, to the satisfaction of the Engineer, before application will be permitted. The presence of moisture can be tested in accordance with the procedures set out in Subsection 626.03.2.4. The application temperature of the thermoplastic material shall be between 400° and 450°F.

Upon request, the Engineer will establish the control points for markings at necessary intervals not to exceed 600 feet on tangents and more often on curves. All additional work necessary to establish intermediate control points shall be performed by the Contractor. On curves, unsightly variations from the normal curvature will not be permitted unless specifically shown on the plans or ordered by the Engineer.

Immediately before application, the areas to receive markings shall be cleaned thoroughly in accordance with Subsection 625.03.2. On areas of pavement cured with compound, the membrane shall be removed completely by shot blasting, sand blasting or other approved method.

Unless otherwise directed by the Engineer, traffic stripes that are coincidental with the thermoplastic stripe shall be removed prior to placement of the thermoplastic material, except that temporary paint stripe may be left in place when satisfactorily placed in the proper location. Any temporary stripe not covered shall be removed. Payment for removal of stripe, except temporary stripe, will be made under Section 202.

When thermoplastic material is to be applied to portland cement concrete pavements or bridge surfaces, a binder-sealer of the type and amount

recommended by the manufacturer of the thermoplastic material shall be applied prior to placement of the thermoplastic material. On other pavement surfaces, a binder-sealer shall be applied under those conditions recommended by the manufacturer of the thermoplastic material.

The thickness of the thermoplastic material, when measured above the surface plane of the pavement, shall be within tolerance of the specified thickness. Unless otherwise specified in the plans or contract documents, the thickness shall be 60 mils for edge lines, 90 mils for center lines, lane lines, barrier lines and detail stripe including gore markings, and 120 mils for crosswalks, stop lines, and railroad, word and symbol markings. The measured thickness at the center of the line shall be no less than the specified thickness with the edge of the line not thinner than 75% of the specified center thickness and will be checked at intervals of one mile or less as directed by the Engineer.

Any thermoplastic traffic marking less than the required thickness shall be corrected by overlaying with an additional application of thermoplastic material. Any such required overlay will be no less than 30 mils. Although a tolerance of 25 percent from center to edge is allowed, a consistent underrun of any amount in thickness will not be acceptable.

Additional beads by the drop-on method shall be applied at a rate of not less than three pounds of beads per 100 feet of six-inch stripe.

All newly applied thermoplastic material shall be protected from traffic until the material is sufficiently dry so as not to sustain damage from vehicle tires. Any material so damaged, marred or picked up by traffic shall be repaired, and the thermoplastic material tracked onto the pavement shall be removed.

The length and width of lines shall be within a tolerance of plus or minus three inches and plus or minus 1/8 inch, respectively. For skip markings, the tolerance for intervals shall not exceed the line length tolerance.

**626.04--Method of Measurement.** Thermoplastic stripe completed in accordance with the plans and specifications will be measured by the mile or by the linear foot, as indicated, from end-to-end of individual stripes. In the case of skip lines the measurement will include skips. The length used to measure centerline, lane lines and edge stripes will be the horizontal length computed along the stationed control line.

Detail traffic stripe will be measured by the linear foot from end-to-end of individual stripes. Measurements will be made along the surface of each stripe and will exclude skip intervals where skips are specified. Stripes more than six inches in width will be converted to equivalent lengths of six-inch stripe.

Legend, which is to include railroad markings, pedestrian crosswalks and stop

lines, will be measured by the square foot or linear foot. Pay areas of individual letters and symbols will usually be shown on the plans and measured by the square foot. Transverse railroad bands, pedestrian crosswalks and stop lines will generally be measured by the linear foot, in which case, stripes more than six inches in width will be converted to equivalent lengths of six-inch widths.

**626.05--Basis of Payment.** Thermoplastic traffic markings will be paid for at the contract unit price per mile, linear foot, or square foot, as applicable, which shall be full compensation for completing the work.

Payment will be made under:

626-A: 6" Thermoplastic Traffic Stripe, Skip White	- per linear foot or mile
626-B: 6" Thermoplastic Traffic Stripe, Continuous White	- per linear foot or mile
626-C: 6" Thermoplastic Edge Stripe, Continuous White	- per linear foot or mile
626-D: 6" Thermoplastic Traffic Stripe, Skip Yellow	- per linear foot or mile
626-E: 6" Thermoplastic Traffic Stripe, Continuous Yellow	- per linear foot or mile
626-F: 6" Thermoplastic Edge Stripe, Continuous Yellow	- per linear foot or mile
626-G: Thermoplastic Detail Stripe, <u>Color</u>	- per linear foot
626-H: Thermoplastic Legend, White	- per linear foot or square foot

**SECTION 627 - RAISED PAVEMENT MARKERS**

**627.01--Description.** This work consists of furnishing and placing pavement markers of the types, colors, shapes, and dimensions specified and in reasonably close conformity with the location, lines, and details shown on the plans or as directed by the Engineer.

**627.02--Materials.** Pavement and jiggle markers of the types specified shall conform to the applicable requirements of Subsection 720.03 and shall be listed on the Department's "Approved Sources of Materials".

Type B through G High Performance reflective markers shall be listed on the Department's "Approved Sources of Materials" for high performance raised pavement markers.

The bituminous adhesive for pavement markers shall meet the requirements of Subsection 720.03.7.

### **627.03--Construction Requirements.**

**627.03.1--General.** Unless waived by the State Construction Engineer on the basis of known performance qualifications, the Contractor or approved subcontractor shall certify to the Engineer that sufficient experience has been acquired in the placement of the required markers, or the Contractor or approved subcontractor shall require the manufacturer of the markers to have a qualified technical representative on or immediately available to the project during the application of the markers to assist the Contractor's personnel in the proper application of the adhesive and markers and to render technical assistance to the Engineer as may be deemed desirable.

Any such waiver shall be subject to the conditions set forth in the waiver.

**627.03.2--Construction Details.** The markers shall be installed when the relative humidity of the air is 80% or less, the pavement surface is dry and the temperature of the pavement surface is no less than 50°F. Other pavement marking materials, such as thermoplastic, cold plastic and paint, shall be placed prior to installation of markers.

The portion of the highway surface to which the marker is to be bonded shall be cleaned so as to be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive.

The bituminous adhesive shall be melted and heated in either thermostatically controlled double boiler type units utilizing heat transfer oil or thermostatically controlled electric heating pots. Direct flame melting units shall not be used. The melter/applicator unit shall be suited for both melting and pumping application through heated applicator hoses.

The adhesive shall be heated to between 375°F and 425°F and applied directly to the pavement surface from the melter/applicator by either pumping or pouring. It is important that application temperature be maintained between 375°F and 425°F as lower temperatures may result in decreased adhesion while higher temperatures may damage the adhesive.

The adhesive should be applied in a puddle approximately two-thirds to three-fourths the diameter of the marker. Markers should be applied to the adhesive

within 10 seconds to assure bonding. The marker shall be placed in position by applying downward pressure until the marker is firmly seated with the required adhesive thickness and squeeze out. Excessive adhesive squeeze out shall be removed from the pavement and adhesive on the exposed surfaces of the markers shall be immediately removed. Soft rags moistened with mineral spirits conforming to Federal Specification TT-T-291 or kerosene may be used if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent shall be used.

All markers shall be installed in a uniform line, with controls established by the Engineer. The Engineer will establish controls for each line of markers by setting control points at not less than approximately 600-foot intervals on tangents and 50-foot intervals on curves. All additional work necessary to establish intermediate control points and individual marker points shall be performed by the Contractor, including smoothing out minor irregularities in any line established by the Engineer. On curves, the line of markers on lane lines and edge lines shall follow the normal curvature of the curve and placement on chords or other variations from the normal curvature will not be permitted, unless specifically shown on the plans or ordered by the Engineer.

Reflective markers shall be installed in such a manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. No markers shall be installed over longitudinal or transverse joints of the pavement surface.

The marker shall be protected against impact until the adhesive has hardened. The Engineer shall be the judge as to the minimum time necessary to cure the adhesive for sufficient set to bear traffic.

The adhesive may be reheated and reused. However, the pot life at application temperatures shall not be exceeded.

Clean out of equipment and tanks may be performed using petroleum solvents such as diesel fuel or similar materials. CAUTION: Be sure that all heating is off before cleaning operations are begun. All solvent must be removed from the equipment tanks and lines before the next use of the melter.

**627.04--Method of Measurement.** Raised pavement markers of the type specified will be measured per each as determined from actual count in place.

**627.05--Basis of Payment.** Raised pavement markers of the type specified will be paid for at the respective contract unit price per each, which shall be full compensation for completing the work.

Payment will be made under:

Section 627	Section 627
627-A: Type A, Non-Reflective White Raised Jiggle Markers	- per each
627-AY: Type AY, Non-Reflective Yellow Raised Jiggle Markers	- per each
627-B: Two-Way Clear Reflective Raised Markers	- per each
627-C: Red-Clear Reflective Raised Markers	- per each
627-D: Two-Way Yellow Reflective Raised Markers	- per each
627-E: One-Way Clear Reflective Raised Markers	- per each
627-F: One-Way Yellow Reflective Raised Markers	- per each
627-G: Yellow-Clear Reflective Raised Markers	- per each
627-H: Chip Seal Reflective Raised Markers	- per each
627-J: Two-Way Clear Reflective High Performance Raised Markers	- per each
627-K: Red-Clear Reflective High Performance Raised Markers	- per each
627-L: Two-Way Yellow Reflective High Performance Raised Markers	- per each
627-M: One-Way Clear Reflective High Performance Raised Markers	- per each
627-N: One-Way Yellow Reflective High Performance Raised Markers	- per each
627-O: Yellow-Clear Reflective High Performance Raised Markers	- per each

## SECTION 628 - COLD PLASTIC PAVEMENT MARKINGS

**628.01--Description.** This work consists of furnishing materials and installing cold plastic pavement markings of the type specified in reasonably close conformity with the plans and these specifications.

Cold plastic traffic markings may be used in lieu of hot applied thermoplastic markings. Substitution will only be allowed for pay items 626-A through H. Substituted cold plastic markings shall be of the same color and width as that required for the hot applied stripe. Unless otherwise specified, the markings, whether hot applied or cold plastic, shall be of the same type material for the

entire project. Material and construction requirements for substituted cold plastic traffic markings shall meet the requirements of this section of the Standard Specifications. The layout and spacing for substituted cold plastic traffic markings will remain as shown in the plans, or in the contract documents, for hot applied thermoplastic markings. Measurement of substituted cold plastic traffic markings shall be made in accordance with this subsection of the Standard Specifications. Payment for substituted cold plastic traffic markings shall be made at the unit price bid for the appropriate hot applied thermoplastic marking.

**628.02--Materials.** Cold plastic marking material shall meet the requirements of Subsection 720.04. High performance cold plastic marking material shall meet the requirements of Subsection 720.07.

**628.03--Construction Requirements.**

**628.03.1--Equipment.** The material manufacturer shall furnish a mechanical applicator for the application of 16-inch wide film. When high performance profile cold plastic pavement markings are used, the manufacturer shall provide application equipment, manual or automatic as necessary for the job requirements. These applicators shall be capable of applying markings to the required alignment and dimensions shown on the plans or in the contract documents. The mechanical applicator shall be provided on location at the time designated and for the duration of the application period. The material manufacturer shall provide technical assistance for operation and maintenance of the mechanical applicator at the discretion of the Engineer.

**628.03.2--General.** The free-air temperature shall be at least 60°F. The pavement surface shall be dry and clean. All dirt, loose particles of pavement, and other foreign material shall be removed prior to application of the pavement marking material. All longitudinal stripes shall be mechanically applied. Detail stripe and legend may be applied manually. Only butt splices without overlay will be permitted for multiple piece and line type markings. Except for legend, the specified width of the markings shall be made in a single tape application. Where possible the markings shall be placed adjacent to rather than on longitudinal construction joints in the pavement. Placement tolerance will be those set out in Subsection 625.03.3. Markings not meeting these tolerances shall be removed and replaced at the Contractor's expense.

**628.03.3--Application.** Both mechanical and manual application shall be in accordance with the manufacturer's instructions. A liquid contact shall be used at the rate recommended by the manufacturer for detail stripe and legend symbols. Liquid contact cement shall not be used elsewhere unless specified by the manufacturer. When liquid contact cement is used, the newly placed markings shall be protected from traffic for the period of time recommended by the manufacturer of the cement.

**628.04--Method of Measurement.** Cold plastic pavement markings will be measured for payment in accordance with Subsection 626.04.

**628.05--Basis of Payment.** Cold plastic pavement markings will be paid for at the contract unit price per mile, linear foot or square foot, as applicable, which shall be full compensation for completing the work.

Payment will be made under:

628-A: 6" Cold Plastic Traffic Stripe, Skip White	- per linear foot or mile
628-B: 6" Cold Plastic Traffic Stripe, Continuous White	- per linear foot or mile
628-C: Blank	
628-D: 6" Cold Plastic Traffic Stripe, Skip Yellow	- per linear foot or mile
628-E: 6" Cold Plastic Traffic Stripe, Continuous Yellow	- per linear foot or mile
628-F: Blank	
628-G: Cold Plastic Detail Stripe, <u>Color</u>	- per linear foot
628-H: Cold Plastic Legend, White	- per square foot or linear foot
628-I: 6" High Performance Cold Plastic Traffic Stripe, Skip White	- per linear foot or mile
628-J: 6" High Performance Cold Plastic Traffic Stripe, Continuous White	- per linear foot or mile
628-K: Blank	
628-L: 6" High Performance Cold Plastic Traffic Stripe, Skip Yellow	- per linear foot or mile
628-M: 6" High Performance Cold Plastic Traffic Stripe, Continuous Yellow	- per linear foot or mile
628-N: Blank	



628-O: High Performance Cold Plastic Detail Stripe, <u>Color</u>	- per linear foot
628-P: High Performance Cold Plastic Legend, White	- per square foot or linear foot

**SECTION 629 - VEHICULAR IMPACT ATTENUATORS**

**629.01--Description.** This work consists of furnishing all materials, components and accessories and installing impact attenuator systems meeting all of the requirements specified on the plans or in other contract documents, and assembled and constructed at the location(s) indicated on the plans or as established by the Engineer.

This work shall also include the installation of median barrier end sections in accordance with the plans, specifications, and the manufacturer's recommendations.

**629.02--Materials.** Materials used in the construction of the vehicular impact attenuator system shall all be new and shall conform to the applicable requirements of the respective section(s) of Section 700, as may be supplemented by requirements in other contract documents for the particular system installation.

The impact attenuators used must be one as shown on the Department's "Approved Sources of Materials". Replacement packages shall consist of spare parts of the expected type and number needed to repair one hit for each attenuator unit installed.

**629.03--Construction Requirements.**

**629.03.1--Fabrication and Construction.** The plans and other contract documents will detail and the system assembly shall be constructed in accordance with the requirements for the fabrication and construction of the attenuator system. For manufactured products specified, unless otherwise indicated in the contract, the system shall be fabricated and installed in accordance with the manufacturer's recommendation; in such case, the Contractor shall obtain the manufacturer's recommended installation instructions, including erection diagrams, and shall furnish the Engineer with a complete copy of such recommended installations and instructions.

In the fabrication and construction of any vehicular impact attenuator system, sharp edges, projections, and any misfits of fabrication or construction shall be avoided.

Installation of impact attenuators shall be accomplished by experienced workmen

in accordance with the recommendations of the manufacturer. As a replacement supply, the Contractor shall furnish a spare parts package. The quantity and materials of this package will be that necessary to repair one hit for each attenuator unit installed. The Contractor shall use these parts to maintain the attenuator until release of maintenance. Upon completion of the work the replacement packages shall become the property of the Contractor.

The median barrier end section and vehicular attenuator back-up wall shall be constructed in accordance with the plans, the manufacturer's recommendations, applicable provisions of Section 615 and other applicable provisions of the Standard Specifications.

**629.04--Method of Measurement.** Vehicular impact attenuators will be measured as a unit for each complete attenuator installed and accepted. One replacement package shall be included in the bid price for each attenuator.

Median barrier end sections and vehicular attenuator back-up wall will be measured as a unit for each complete and accepted section.

Foundations for attenuators and median barrier end sections are considered parts of the respective units and will not be measured for separate payment.

**629.05--Basis of Payment.** Vehicular impact attenuators, median barrier end sections and vehicular attenuator back-up wall will be paid for at the contract unit price per each. In the event an additional replacement package is required during the life of the contract, 25% of the lump sum price will be allowed to place the unit back in operation. Payment for the above listed units shall be full compensation for the work and materials required under this Section.

Payment will be made under:

- 629-A: Vehicular Impact Attenuator, Speed Rating - per each
- 629-B: Median Barrier End Section - per each
- 629-C: Vehicular Impact Attenuator Back-up Wall - per each

**SECTION 630 - TRAFFIC SIGNS AND DELINEATORS**

**630.01--Description.** This work consists of furnishing and installing delineators, traffic signs, sign supports, framing, and panels in reasonably close conformity with the requirements shown on the plans and set out in these specifications.

The work and materials shall conform to the requirements of the MUTCD, current on the date of receipt of bids, except as modified by these specifications

or as shown on the plans.

The bidder or the bidder's proposed supplier may be required to show satisfactory evidence of successful experience in fabrication of reflectorized multi-panel highway signs prior to award of the contract. Bidders may also be required to show evidence of successful experience or capability in erection of reflectorized multi-panel highway signs.

When specified as Contractor Designed Metal Overhead Sign Supports, the Contractor will be responsible for the design of the metal overhead sign support(s) and overhead sign supports on bridges(s). The design shall meet the latest requirements of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

The Contractor shall submit to the Bridge Engineer a design using steel. The design shall be a rectangular box truss. Design drawings, calculations and other necessary supporting data shall be submitted as soon as possible after the Pre-Construction Conference. The design shall be prepared by a Professional Engineer registered in the State of Mississippi proficient in the design of overhead sign structures.

The design wind speed shall be a minimum of 70 mph. Overhead sign supports shall be designed to support, in addition to loads required in the design specifications, a uniform load of 40 pounds per linear foot applied to the vertical truss to which the signs are attached, extending along the truss across the roadway below from points four feet outside each outer edge of pavement, unless otherwise specified.

**630.02--Materials.** Materials for signs and delineators shall meet the requirements of Section 721.

Although certain particular brands, makes of materials, devices, processes, and/or equipment are named herein for the purpose of establishing minimum acceptable standards, it is neither implied nor intended that those named are to be considered to the exclusion of comparable brands, materials, devices, processes, or equipment.

All warranties, guaranties, and instruction sheets normally furnished by the manufacturer for materials and supplies used in the work shall be delivered to the Engineer prior to final acceptance of the project.

Material for Contractor designed metal overhead sign supports shall meet the following:

Reinforcing Steel. Reinforcing steel used in reinforced concrete footings shall be in accordance with Subsection 602 and meet the requirements of ASTM

Designation: A 615, Grade 60.

Anchor Bolts. Material for anchor bolts shall meet the requirements of ASTM Designation: A 36; anchor bolts shall be hot-dipped galvanized in accordance with ASTM Designation: A 153, Class C; threads and nuts for anchor bolts shall be lubricated with a visible dye so that a visual check can be made for proper lubrication prior to installation.

Structural Steel. Material for posts, chords and bracing members shall meet the requirements of ASTM Designation: A 501 or ASTM Designation: A 53, Grade B.

Material for structural shapes, plates, posts and chord caps shall meet the requirements of ASTM Designation: A 36.

Material for round tapered monotube shall meet the requirements of ASTM Designation: A 595, Grade A.

**630.02.1--Fabrication of Signs and Sign Panels.** Signs shall be fabricated in a properly equipped shop owned and operated by the Contractor or approved subcontractor or supplier.

**630.02.2--Fabrication of Aluminum Extrusions and Sheets.** The fabrication of aluminum extrusions and sheets shall generally conform to or be equivalent to the fabrication methods and practices recommended in the handbook of the major producers of aluminum materials and the following specific requirements:

- (a) Materials shall be sawed or milled. Sheets 1/2 inch or less in thickness may be sawed, blanked, sheared, or milled.
- (b) Flame cutting will not be permitted.
- (c) Re-entrant cuts shall be avoided wherever possible. If used, they shall be filleted by drilling prior to cutting.
- (d) Holes in extrusions shall be drilled.
- (e) Holes in sheet aluminum may be drilled to finish size or they may be blanked to finished size provided the diameter of the blanked hole is at least twice the thickness of the metal being blanked.
- (f) Aluminum shall be free of buckles, warp, dents, cockles, burrs, ragged breaks, and defects resulting from fabrication. Cut edges shall be true and smooth. The surface shall be flat.
- (g) Before placing aluminum in contact with steel, the steel surface shall be

coated by galvanizing. Aluminum alloys shall not be placed in contact with copper, copper base alloys, lead, or nickel.

- (h) In handling, precautions shall be taken to prevent scratches, gouges, and abrasion.

**630.02.3--Preparation of Aluminum for the Application of Reflective Sheeting.** Extruded aluminum and flat sheet aluminum sign panels to which reflective sheeting is to be applied shall be prepared as follows:

Preliminary Cleaning. The panel shall be completely submerged in a six percent (6%) solution of an inhibited alkaline cleaner at 160°F to 180°F for three minutes, followed by a thorough rinse with clean, running cold water. A grease solvent such as mineral spirits or naphtha, conforming to ASTM Designation: D 235, or trichloroethylene, conforming to ASTM Designation: D 4080, may be used.

Surface Preparation. For flat sheet aluminum, preliminary cleaning shall be followed by a surface treatment with a six to eight percent (6% to 8%) solution of phosphoric acid applied to the surface by immersion or brushing. The solution shall be allowed to remain on the surface for five minutes and then thoroughly rinsed with running cold water followed by hot water tank rinse.

Drying. The panels shall be dried by the use of forced warm air.

Handling. Metal shall not be handled except by device or clean canvas gloves between all cleaning and etching operations and the application of reflective sheeting. There shall be no opportunity for metal to come in contact with grease, oils, or other contaminants prior to painting.

**630.02.4--Preparation of Aluminum for Painting.** Aluminum which is to be painted shall be cleaned and prepared by a process conforming to ASTM Designation: D 1730, Type B Chemical Treatment. Metal shall not be handled except by device or clean canvas gloves between all cleaning and etching operations and the application of paint. There shall be no opportunity for metal to come in contact with greases, oils, or other contaminants prior to painting.

**630.02.5--Blank.**

**630.02.6--Blank.**

**630.02.7--Reflective Sheeting.** Reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified for by the sheeting manufacturer. Type II adhesive coated sheeting shall be pre-perforated.

Sign faces comprising two or more pieces of panels of reflective sheeting shall be

carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance during both day and night. Alternate, successive width sections of either sheeting or panels must be reversed and consecutive to insure that corresponding edges of reflective sheeting lie adjacent on finished sign. Non-conformance may result in non-uniform shading and an undesirable contrast between adjacent width of applied sheeting which will not be acceptable.

At splices, Type I adhesive coated sheeting shall be over-lapped at least 3/16 inch. Type II adhesive coated sheeting may be spliced with an overlap of at least 3/16 inch or butted with a gap not to exceed 1/32 inch. Only butt splices will be permitted with transparent screen processing. Sheeting applied to extruded sections shall extend over top edges and down side legs a minimum of 1/16 inch.

Reflective sheeting splices and sign edges shall be sealed with materials supplied and in the manner specified by the sheeting manufacture.

**630.02.8--Removable Copy.** Removable letters, numerals, symbols, and border are to be placed on the sign in accordance with the plans or as directed by the Engineer. This removable copy shall be attached to the sign from the front by means of a huck or cherry rivet gun and aluminum pull-through rivets without the use of clips.

Route markers used on structural panels with removable copy shall be made up as standard route markers on flat sheet metal as specified and shall be riveted to the structural panel. These route markers will not be paid for as separate signs but shall be considered as part of the major sign to which they are affixed.

**630.02.9--Silk Screening.** Where specified on the plans, sign letters, numerals, symbols, and border shall be applied to the sign panel by direct or reverse silk screen method. The letters shall be in accordance with the plans and series letters as set out by "Standard Alphabets for Highway Signs" which can be obtained from the Federal Highway Administration.

Unless otherwise specified, all silk screen legend shall be on silver-white or yellow reflective sheeting background.

Screening shall be accomplished in the manner specified by the sheeting manufacturer. Processing may be accomplished either before or after application of the sheeting to the flat, smooth base panels.

**630.02.10--Packing, Storing and Shipping Signs.** Signs shall be slip sheeted and packed in such a manner as to insure their arrival at their destination in undamaged condition. Signs shall be stored on edge in a cool, dry place, and shall not be allowed to become wet during shipment or storage.

**630.02.11--Shop Drawings.** The Contractor shall submit for the approval of the

Engineer scale drawings of all sign faces, showing arrangements and spacing of all letters, numerals, symbols, and border. For each type of sign support to be used with each different type of sign panel, the Contractor shall submit detailed drawings of the proposed method of attaching the sign to the supports on all signs not detailed on the plans. Shop drawings of all individual removable letters, numerals and symbols as well as layout templates for silk screens shall be submitted to the Engineer for approval before templates or screens are made.

**630.02.12--Welding.** Any welding shall conform to the requirements of Subsection 630.03.8. Welding for Contractor designed metal overhead sign supports shall conform to the latest edition of AWS D1.1 for structural steel.

### **630.03--Construction Requirements.**

**630.03.1--Construction Stakes.** Unless the contract has provisions for construction staking by the Contractor, the Engineer will furnish and set construction stakes for signs and will furnish the Contractor with all required information relating to lines and grades.

The Contractor shall check all leading dimensions and clearances measured from such stakes and thereafter will be responsible for orientation, elevation, offset, and level of all signs so erected.

**630.03.2--Sign Positioning.** The glossy surface on sign faces may produce specular reflection. Signs shall be positioned to eliminate or minimize specular reflection.

**630.03.2.1--Overhead Signs.** Unless otherwise directed by the Engineer, signs shall be erected at right angles to the road and so that the sign face is tilted back or is vertical as determined by the approach grade of the roadway or shown on the plans.

**630.03.2.2--Ground-Mounted Signs.** Signs shall be erected so that the sign face is truly vertical and at 93 degrees away from the center of the lane which the sign serves and the direction of travel unless otherwise directed by the Engineer. Where lanes divide and on curves, sign faces shall be oriented so as to be most effective both day and night and to avoid the possibility of specular reflection.

**630.03.2.3--Vertical and Horizontal Clearances.** All signs shall be installed so as to meet the vertical and horizontal clearances shown on the plans or if not shown the minimum clearance given in the MUTCD shall apply.

**630.03.3--Excavation.** The Contractor shall perform the excavation required for sign installation to neat lines by suitable means.

**630.03.4--Posts.** All posts shall be set at the required line and grade. Unless

otherwise shown on the plans, all posts except delineator posts shall be set in Class "B" concrete. Any required reinforcing steel will be shown on plans. Exposed concrete shall be finished with a steel float to the slope shown on the plans.

Footings for overhead sign supports shall be Class "B" concrete and shall be in accordance with the required dimensions, alignment, grades, reinforcement, and method of placement shown on the plans.

Treated timber posts shall be set in holes of the specified depth and of sufficient diameter to allow proper tamping and compaction or backfill. The backfill shall be made with the most suitable earth available and shall be tamped until the post is firm and rigid in a vertical position.

Pipes used for posts shall be capped by suitable means to exclude moisture.

**630.03.5--Framing.** Framing for ground-mounted signs shall be as shown on the plans. Holes may be field punched as permitted by the Engineer. All steel used for framing shall be galvanized.

**630.03.6--Erection of Signs.** Signs shall be erected in a neat and workmanlike manner.

After installation is complete, signs will be inspected at night by the Engineer. If specular reflection is apparent on a sign, its positioning shall be adjusted by the Contractor to eliminate this condition.

**630.03.7--Erection of Delineators.** The location of each type of delineators shall be as shown on the plans. The post shall be driven and a driving cap used to protect the curb. Posts shall be driven vertically and driving caps used to protect the posts. Delineator shall be attached to the posts as shown on the plans by means of a huck or cherry tool and aluminum fastener.

**630.03.8--Overhead Sign Supports.**

**630.03.8.1--Fabrication.** Metal overhead sign support structures shall be either all aluminum or all steel. They shall be fabricated as shown on the plans in a properly equipped plant. All welds shall be performed in the shop by certified welders. Welding for steel structures shall conform to the requirements of Subsections 810.03.5 and 810.03.6.

Welding for aluminum structures shall meet the requirements for the fabrication of welded aluminum structures as set out in the AASHTO Standard Specifications for Structural Supports for Highway Signs, except that the filler metals to be used with particular base metals shall be as specified in Subsection 721.03.3.



Unless a particular edition of the AASHTO specifications is indicated on the plans, the edition current at the time of receipt of bids shall be applicable.

Prior to installation, the surface of aluminum shoe bases to be placed in contact with concrete shall be given a heavy coat of an alkali-resistant black coal tar epoxy paint meeting the requirements of Steel Structures Painting Council Paint Specification No. SSPC-Paint 16. The paint shall be applied in accordance with the manufacturer's recommendation and as it is received from the manufacturer without the addition of thinner.

The Contractor may provide a neoprene pad of the dimensions and shape shown on the plans to be placed between the aluminum shoe bases and the concrete as a substitute for the shoe-base paint requirements.

Each Contractor designed metal overhead sign support structure shall be match-marked and assembled in the shop for inspection prior to shipment.

**630.03.8.2--Shop Drawings.** Shop drawings of the structures shall be submitted for approval in accordance with Subsection 810.02.2. They shall show the required vertical camber for the horizontal support and method of fabricating, including welding procedure.

Shop drawings and design calculations for Contractor designed metal overhead sign supports shall be submitted to the Bridge Engineer in triplicate for review prior to fabrication. Shop drawings shall show all members, connections (welds), footings and details necessary for a complete structure. The required truss camber and method of fabricating shall also be shown.

**630.03.8.3--Inspection and Testing.** Unless waived in writing by the Engineer, inspection of the fabrication will be required. Each structure shall be match marked and assembled in the shop prior to inspection. Steel structures to be galvanized shall be match marked and assembled for inspection prior to galvanizing. Additional inspections for galvanized steel structures may be required before and/or after galvanizing. The Engineer shall be notified at least 24 hours prior to the time that an inspection is scheduled. The structures shall be checked for alignment, sound welds, and general workmanship. Four copies of a certification by the galvanizer that galvanizing meets the appropriate specification shall be furnished to the State Materials Engineer. Mill test reports on material in primary members shall be submitted in accordance with Subsection 810.03.25.

Shop inspection is required for Contractor designed metal overhead sign supports to ensure that fabrication and welding comply with the contract requirements. A commercial testing laboratory retained by the Department will perform the inspection but this inspection does not relieve the fabricator of any responsibility regarding complying with the contract requirements. A pre-fabrication

conference shall be required unless waived by the Bridge Engineer. No fabrication of any structure shall begin until approved drawings and welding procedures have been distributed, the pre-fabrication conference held, and authorization for the work to begin given by the Bridge Engineer.

**630.03.9--Removal of In-Place Signs, Markers and Posts.** The Contractor shall salvage existing signs, markers, and posts and stockpile them at the locations shown on the plans. Signs and markers shall be removed from posts and be stacked on edge with paper separators between units. Posts shall be pulled without being bent and stockpiled off the ground. All handling, hauling, and storing shall be such as to avoid damage. This work shall be incidental to items of the contract, and separate payment will not be allowed.

**630.03.10--Bolt Connections for Contractor Designed Metal Overhead Sign Supports.** High-strength bolts shall meet the requirements of ASTM Designation: A 325, Type I and shall be no larger than one inch (1") in diameter; bolts other than high-strength shall meet the requirements of ASTM Designation: A 307, Grade A. Nuts for all bolts shall meet the requirements of ASTM Designation: A 563; nuts for high-strength bolts shall be heavy hex, Grade DH; nuts for all other bolts shall be hex, Grade A; all nuts shall be lubricated with a visible dye so that a visual check can be made for proper lubrication prior to installation. All washers shall meet the requirements of ASTM Designation: F 436. All fasteners (bolts, nuts and washers) shall be galvanized in accordance with ASTM Designation: A 153, Class C. All connections using high strength bolts require Direct Tension Indicators (DTIs). DTIs shall meet the requirements of ASTM Designation: F 959-90 and shall be mechanically galvanized in accordance with ASTM Designation: B 695, Class 50 coating.

**630.03.11--Galvanizing for Contractor Designed Metal Overhead Sign Supports.** Steel assemblies shall be galvanized after fabrication in accordance with the latest requirements of ASTM Designation: A 123. Damage to the galvanized coating shall be repaired subsequent to erection by a method approved by the Bridge Engineer. Holes may be drilled in structural steel members as needed for venting during galvanizing. Such holes shall be in accordance with the following requirements: No holes shall be greater than eleven sixteenths inch (11/16") in diameter; holes for bracing members of columns and trusses may be drilled in either the wall of the bracing member or the wall of the column post or truss chord at each end, except for trusses, no holes shall be drilled in the wall of vertical diagonals and no holes shall be drilled in wall of chords at either end of horizontal struts, horizontal diagonals or interior diagonals. Holes drilled in the wall of vertical struts for trusses shall face toward the center of the truss; holes drilled in the wall of all other bracing members shall be located so that they face downward when the structures are erected. When necessary, one hole for a member may face upward if there is an opposite hole facing downward. No bracing member shall have more than one hole at each end. Holes shall be drilled and shall be located at a distance not to exceed the

outside diameter of the member from the end of the member.

**630.03.12--Final Cleaning Up.** The Contractor shall remove all rejected and unused materials and debris from the right-of-way. Shoulders and slopes shall be restored to their original condition. Excess excavation shall be disposed of off the right-of-way at the Contractor's expense unless otherwise directed by the Engineer. Before final inspection, the Contractor shall perform such touching up of paint finishes, cleaning of exposed sign and support surfaces, and other cleaning up as may be necessary to insure the effectiveness and neat appearance of the work.

**630.04--Method of Measurement.** Standard sheet aluminum signs will be measured by the square foot of sign face for each specified thickness.

Extruded aluminum signs, including removable copy, will be measured by the square foot of sign face.

Built-up steel panel signs, including removable copy, will be measured by the square foot of sign face. Structural steel used in building up the sign panel system will not be measured for separate payment.

In determining the area of sign faces, no deduction will be made for corner radii or mounting holes. The area of octagonal signs, U.S. shields, and Interstate shields will be computed as the area of the circumscribing square or rectangle. The area of the triangular signs will be computed as the area of the triangle.

Steel U-section posts will be measured by the linear foot of each specified size.

Timber posts will be measured by the unit.

Structural steel beams for vertical sign supports will be measured by the linear foot of each specified size.

Structural steel angles and bars, or channels, used for lateral bracing of vertical sign supports will be measured by the pound.

Steel pipe posts will be measured by the linear foot of each specified size.

Concrete for overhead sign support foundations will not be measured for separate payment. Such costs shall be included in the cost of the overhead sign assembly. Concrete for roadside signs will be measured in cubic yards in accordance with Section 601. In computing the volume, the neat dimensions shown on the plans will be used except for variations as may be ordered by the Engineer.

Reinforcement, when called for on the plans, will be measured in pounds in accordance with Section 602.

Excavation will not be measured for separate payment and the cost thereof shall be considered incidental to and included in the unit prices bid for footings, posts, etc.

Paint and painting will not be measured for separate payment and the cost thereof shall be included in unit prices bid for items painted.

Metal overhead sign support assemblies will be measured by the unit.

Delineators and object markers will be measured by the unit, including post, fastener, and single or multiple units as specified.

**630.05--Basis of Payment.** Signing items, measured as prescribed above, will be paid for at the respective contract unit or lump sum price, which price shall be full compensation for completing the work.

Payment will be made under:

630-A: Standard Roadside Signs, <u>Description</u>	- per square foot
630-B: Interstate Directional Signs, <u>Description</u>	- per square foot
630-C: Steel U-Section Posts, <u>Weight</u>	- per linear foot
630-D: Structural Steel Beams, <u>Description</u>	- per linear foot
630-E: Structural Steel Angles and Bars, <u>Description</u>	- per pound
630-F: Delineators, <u>Mounting</u> , <u>Description</u>	- per each
630-G: Type ____ Object Markers, <u>Description</u> , <u>Mounting</u> , <u>Color</u>	- per each
630-H: Treated Timber Posts, <u>Size and Length</u>	- per each
630-I: Metal Overhead Sign Supports, Assembly No. ____, <u>*</u>	- lump sum
630-J: Overhead Sign Supported on Bridge, Assembly No. ____, <u>*</u>	- lump sum
630-K: Welded & Seamless Steel Pipe Posts, <u>Size</u>	- per linear foot

\* Indicate when the sign is "Contractor Designed"

SECTION 631 - FLOWABLE FILL

**631.01--Description.** This work shall consist of furnishing and placing a flowable fill material. Uses include, but are not limited to, placement under existing bridges, around or within box culverts or pipe culverts, or at other locations shown on the plans.

**631.02--Materials.** All materials shall meet the requirements of the following Subsections, or as stated herein:

Fine Aggregate.....	*
Portland Cement .....	701.01 and 701.02
Fly Ash .....	714.05
Air Entraining Admixtures ** .....	713.02
Water .....	714.01.0 and 714.01.2

\* Fine Aggregate gradation shall be fine enough to stay in suspension in the mortar to the extent required for proper flow and shall conform to the following grading:

<u>Sieve Size</u>	<u>% Passing</u>
1/2 inch	100
No. 200	< 1

\*\* High air generators shall be used. These generators increase the fill’s air content to 15 - 35% while reducing settlement and bleed water. Only approved air generators will be allowed to be used to obtain the required air content.

**631.02.1--Mix Design.** Flowable fill is a mixture of Portland cement, fly ash, fine aggregate, air entraining admixture and/or high air generators and water. Flowable fill contains a low cementitious content for reduced strength development.

The consistency of the fresh mixture shall be that of a thin slurry. It shall be tested by filling an open-ended three-inch diameter by six-inches high cylinder to the top. With the mixture in the cylinder, immediately pull straight up. The correct consistency of the mixture will produce an approximate eight-inch diameter circular-type spread with no segregation. Adjustments of the proportions of fine aggregate and/or water may be made to achieve proper solid suspension and optimum flowability; however, the theoretical yield shall be maintained at one cubic yard for the given batch weights.

The Contractor shall submit mix designs for flowable fill to the Engineer to be verified by the Materials Division. The following table is a guide for proportioning flowable fill.

Material	Amount
Cement Type I	75 - 150 lbs/yd <sup>3</sup>
Fly Ash	150 - 600 lbs/yd <sup>3</sup>
Fine Aggregate	*
Water	**
Air <sup>†</sup>	15 - 35%
28 Day Compressive Strength <sup>†</sup>	Minimum 125 psi
Unit Weight, Wet <sup>†</sup>	90 - 110 lbs/ft <sup>3</sup>

\* Fine Aggregate proportioned to yield one cubic yard as verified by unit weight.

\*\* Mix designs shall produce a consistency that will result in a flowable self-leveling product at time of placement.

† The requirements for percent air, compressive strength and unit weight are for Laboratory designs only and are not intended for jobsite acceptance requirements. An accepted air-generating admixture shall be used when no settlement is required.

**631.02.2--Acceptance of Mix.** The acceptance of the mix design shall be based on primary properties that include compressive strength, air content, hardening time, flowability, yield and settlement. This test data shall be submitted with the mix design. Continued use and acceptance, which will be based on the performance of the mix placed, will be at the discretion of the Engineer.

**631.02.3--Manufacturing.** Flowable fill will be manufactured at plants in accordance with Section 804.

**631.03--Construction Requirements.** Prior to placing flowable fill, each end of the structure shall be plugged leaving an opening at each end no larger than necessary to accommodate the filling equipment. Flowable fill shall be discharged from the mixer by any reasonable means into the area to be filled. Unless otherwise approved by the Engineer, filling will begin on the downstream end of the structure and continue until no further material will enter the structure. The flowable fill will then be continued from the upstream end of the structure.

**631.04--Method of Measurement.** Flowable fill will be measured by the cubic yard which will be determined by calculating yield. The yield will be calculated by dividing the actual batch weights of each load by the unit weight of the mix, which will be determined by testing the first load placed on each production day.

**631.05--Basis of Payment.** Flowable fill, measured as prescribed above, will be paid for at the contract unit price per cubic yard, which price shall be full compensation for furnishing all labor, equipment, tools and materials to complete

the work.

Payment will be made under:

631-A: Flowable Fill

- per cubic yard

## **SECTION 634 - TRAFFIC SIGNAL SYSTEMS -- GENERAL**

### **634.01--Description.**

**634.01.1--General.** This section together with the pay item sections covering individual components and the contract plans are intended to describe and include materials and work necessary for completion of traffic signal installations. All work, materials, or methods which may be necessary for completion of the several units which are not specifically mentioned in these specifications or on the plans shall be furnished as incidental to the pay items of the contract and the cost included in the respective contract prices bid.

**634.01.2--Scope of Work.** Work shall consist of furnishing and installing, modifying, or removing loop detector assemblies, shielded cable, detector amplifiers, detector equipment boxes, traffic signals and equipment poles, traffic signal heads, pre-timed controllers, solid state traffic actuated controllers, traffic signal conduit, electric cable, electrical junction boxes, and all incidentals necessary for a complete traffic control signal system installed, tested, and connected.

Where an existing system is (1) required to be modified under the contract, (2) required to be substantially replaced with new equipment but some elements of the existing system are to be retained, or (3) when the entire system is to be replaced, the Contractor shall reuse, if and as required, certain existing materials in the revised system, or shall dismantle and remove, salvage, and stockpile existing materials not specified to remain, or shall abandon such materials, all as shown on the plans, as specified in the special provisions, or as directed by the Engineer. Unless materials designated to be abandoned are shown to become the property of the Contractor for removal and disposal, the term "abandoned" shall indicate abandoned by the Contractor and fully protected by the Contractor for dismantling and removal or other disposal by the State or local jurisdiction having authority.

Unless the contract contains an item of Clearing and Grubbing or Removal of Structures and Obstructions, all such reuse, salvaging and stockpiling, removing or abandoning, and protecting of existing materials shall be performed by the Contractor and the cost thereof absorbed in other items of work under the contract.

The installations shall be carried out in strict conformity with all requirements stated or implied on the plans and in the specifications, and upon completion shall present a neat and finished appearance. All work and materials shall be subject to inspection at all times.

The locations shown on plans are diagrammatical and subject to slight changes as the Engineer may direct. The Contractor shall submit four complete sets of plans upon completion of the work showing all buried cable locations, field wiring schemes and color coding, pavement crossings, etc., in relation to fixed objects. The Contractor shall record all locations on a day-to-day basis.

All work shall be performed in strict accordance with applicable requirements of The National Electrical Code, The Insulated Cable Engineers Association specifications, The National Electric Manufacturers Association recommendations, and requirements of the local utility supplying the electric energy.

#### **634.02--Materials.**

**634.02.1--General.** All materials shall be of the best quality and workmanship and shall be new and of the most advanced proven design available. Throughout the project all units of any one item shall be made by the same manufacturer, but not all the items are required to be made by the same manufacturer. Such items are detector equipment boxes, pre-timed controllers, solid state traffic actuated controllers, traffic signal and equipment poles, detector amplifiers, conventional traffic signal heads, and optically programmed traffic signal heads.

Reference to any name, make, or manufacturer's number for an article of material or equipment is intended to be descriptive, but not restrictive, and is intended to indicate the quality of materials that will be acceptable.

The Contractor may propose the use of other manufacturer's materials on a basis of equality for the purpose intended. Substitutes which may be offered will be subject in every respect to the requirements set forth, and the Contractor shall submit detailed specifications and descriptions of such materials which will be subject to approval by the Engineer.

**634.02.2--Equipment List and Engineering Data.** As an aid to the Contractor in the procurement of required materials and as an aid to the State in the process of monitoring acceptability of manufactured materials and products, the Contractor shall, unless waived in writing by the Engineer, submit to the Engineer a list of manufactured articles, units, components, and materials which the Contractor proposes to install. The list shall be accompanied by adequate engineering data, including essential shop drawings, schematic diagrams, etc. The list shall identify the manufacturer and contain the identifying number of other identifying descriptions of each item. The list shall also be accompanied by



such other engineering or performance data as specified in other applicable sections of the specifications and on the plans.

Five sets of the indicated data shall be submitted.

The Engineer will notify the Contractor in writing of the findings. Any approval given will be an indication that the Engineer has considered that the materials or products, if manufactured and furnished in accordance with the data submitted, could be certified by the manufacturer in accordance with the provisions and requirements of Subsection 106.04, and any approval given shall be subject to such subsection and other applicable provisions of the contract.

If during the process of review of the indicated data, the Engineer requires the Contractor to submit sample articles for review, the sample articles remain the property of the Contractor only if requested in writing at the time of submission. In such case the article will be subject to return to the Contractor upon request without cost to the State.

The equipment list and engineering data as indicated herein shall be submitted within 30 days following execution of the contract. Any required submission after the initial submission to the Engineer shall be made within 15 days following the Engineer's request. The time allowed for review and reporting of the Engineer's findings to the Contractor shall be 30 days from the time of receipt of the initial data or 15 days after receipt of required subsequent data or samples, whichever is the latter date.

**634.02.3--Regulations and Code.** Where not specifically stated in these specifications, all electrical equipment and workmanship shall conform to the applicable requirements of NEMA, ICEA-NEMA, EIA, IES, ITE, ASTM, UL, and the utility company supplying the current where applicable.

Where abbreviations are used in these specifications, such as, in the case of relays, etc., N.O. and N.C. meaning "Normally Open" and "Normally Closed" respectively, or other terms not clearly defined, the meaning shall be understood to be that defined or used by the trade in the respective regulatory specifications and codes.

**634.02.4--Operations.** The Contractor shall furnish all labor, tools, equipment, motive power, barriers, and related items required or necessary to perform the work under the contract in a careful safe manner, properly, and expeditiously.

The Contractor shall conduct the work at all times in such a manner as to insure the least possible inconvenience to public travel, and to property owners on the streets, alleys, and other public places where the construction is to be done.

If underground utilities are in place or are encountered during excavation or other

operations, all necessary protection from injury thereof shall be provided by the Contractor. In order to facilitate such protection, it shall be the responsibility of the Contractor to solicit the assistance and cooperation of the owners of any utility or structure which may be in conflict with any of the Contractor's operations, and the Contractor shall fully cooperate with such utility in accordance with the provisions and requirements of Subsection 107.18. The Contractor shall save the State harmless from any additional cost incurred because of injury or damage by Contractor operations to any utility or structure. The repairs of any utility must be satisfactory to the owners, and insofar as physical condition and presence of the repaired utility shall be satisfactory to the Engineer.

Unless otherwise specified in the contract, for any traffic signal system where an existing system is used to provide control of the movement of the traffic, the following shall be applicable:

- (a) No part of the new traffic control system, required under the contract for that location shall be activated for controlling the traffic until all elements of the system(s) required for that location are complete and have been tested for operational completeness and effectiveness, and until such time all existing traffic control facilities and services shall remain in operation;
- (b) No part of the existing facility(ies) shall be altered, dismantled or removed without the confirmed permission of the Engineer;
- (c) When it is necessary or the Contractor is permitted to relocate a component of existing signal facilities because of required construction operations, the Contractor shall first obtain approval of the Engineer for procedures proposed and shall make such temporary approved removals and relocations as are necessary because of required construction. The Contractor shall utilize existing materials, equipment, and facilities and/or install and extend as necessary to maintain the effectiveness of existing system with the minimum interruption permitted by the Engineer, all at no additional cost to the State;
- (d) The State or local agency will continue operation and maintenance of existing traffic signals, will furnish electrical power for operation of the existing facilities, and will repair or replace facilities damaged by public traffic.

However, at such time the Contractor relocates any component of an existing traffic signal installation as required in the paragraph (c) above, the responsibility for maintenance and repair of all traffic signal installations located within the project limits shall become that of the Contractor. The State or local agency will continue to furnish electrical

power for operation of the traffic signals.

When notified of needed maintenance or repair, the Contractor shall respond within the hour to restore service or provide for other qualified repair personnel to restore service. In addition, the Contractor shall immediately notify the Engineer of action taken.

The Engineer in conjunction with the Traffic Engineering Division may, depending upon the level of service, waive the required one-hour response.

The Contractor shall provide the Engineer with the names and telephone numbers of those responsible for maintenance of the existing and new signals. The Contractor shall have at least one person who can be contacted 24 hours a day;

- (e) Where damage is caused by the Contractor's operations, the Contractor shall at no additional cost to the State, repair or replace damaged facilities promptly in accordance with these specifications. Should the Contractor fail to perform the required repairs or replacements immediately, the State or local authority may at its discretion provide manual temporary traffic control services. Such repairs or replacements will be deducted from moneys due or to become due the Contractor;
- (f) It shall be the Contractor's responsibility to hood or otherwise cover or make ineffective to the satisfaction of the Engineer all signs, signal heads, and messages, including those for control of pedestrian traffic, of the work being constructed until completion of all of the work in the system and the Engineer has given permission to activate the new system for control of traffic and deactivate the existing system; and
- (g) The provisions herein contained for the deactivation of an existing system and the activation of a new system shall be applicable to all types of existing systems whether they are stop-sign controlled, pre-timed signal controlled, traffic actuated signal controlled, or any combination of controls.
- (h) Traffic signal timings must be set in compliance with Department Standards. In order to obtain time settings not shown on the plans, the Contractor shall notify the Engineer at least one week in advance of the need for setting the timings. No timings shall be used that have not been provided by the Engineer. A written record of the timings shall be left in the cabinet.

The Contractor shall make arrangements for power necessary to perform all work required under the contract.

The existing electric power supply, if any, provided by the State or local authority for the operation of the existing signal system at that location will continue to be furnished by the State or local authority for the operation of the existing facility until removal is authorized, and for the operation of the new system during the Satisfactory Performance Period required in Subsection 634.03.3. It shall be the Contractor's responsibility, without additional cost to the State, to make such connections, if any, as are necessary to connect to the existing electric power supply of the State or local authority for power to operate the system during the satisfactory performance period.

It shall be the Contractor's responsibility, without additional cost to the State, to make the necessary arrangements with the local power company to provide electrical service for any installation that does not have an existing power service. The Contractor shall pay for all deposits, hook-up charges, or other initial fees required by the power company. The State or local authority will pay the monthly service bill for the new installation.

The Contractor shall require the manufacturer to begin the warranty or guaranty period of warranties and guaranties required in Subsection 106.01.2 not sooner than 30 days before the article, unit, component, materials, or product is installed in the work and the signal system is complete, or the Contractor shall furnish the Engineer, in a form approved by the Department, similar warranties and guaranties as covenants under the contract and contract bond for an extended period of time equal to the lapse of time between the beginning date of the manufacturer's warranty or guaranty and the date occurring 30 days prior to the date of installation and satisfactory performance in the work.

**634.02.5--Prequalification.** In addition to meeting the appropriate specifications, if the Contractor proposes to use traffic signal controllers, time switches, conflict monitors, load switches, time base coordinators, signal heads, or detector amplifiers that are not currently used by the Department, the equipment manufacturer shall provide the Department with certification that at least 50 units of the model proposed have been in field use for at least two years by at least five organizations. This certification shall include the names of the organizations using the equipment, the responsible persons in the organizations, and the particular locations where the equipment is used. These locations shall not include those where prototype equipment is installed or those where the equipment is being field tested. The State reserves the right of approval for use until these organizations are contacted. If the equipment has not functioned properly in the field, the State may deny approval for use.

The equipment proposed shall meet or exceed the latest NEMA standards for the particular items. The manufacturer shall provide certification that these standards are met. In addition, copies of the laboratory reports and the test procedures shall be provided to determine that the equipment meets the environmental standards set forth by NEMA. Once this equipment is approved for use and then installed

by the Contractor and final acceptance is made by the Department, it shall be considered to be under field testing for a period of at least one year. During this time the Department will maintain the equipment and keep accurate records of any malfunctions that occur. At the completion of this test period, the Department will determine if the equipment will be suitable for use on future projects. The manufacturer shall also assure the Department that a factory authorized technician will be readily available to assist in installation and maintenance of the equipment. The name or names of the technicians shall be provided to the Department prior to final acceptance.

### **634.03--Construction Requirements.**

**634.03.1--General.** The installation of the various types of equipment shall be carried out in compliance with the requirements stated in the sections herein covering the individual components required to complete the traffic signal system and in conformity with the details shown on the plans. Upon completion of the work all equipment shall present a neat and workmanlike finished appearance. Upon completion of the work and before final payment is made, the Contractor shall remove all excess materials from excavation, reshape and resod any portion of the highway which may have been disturbed by construction operations, and leave the project in a neat and sightly condition.

### **634.03.2--Performance Tests.**

**634.03.2.1--Circuit Continuity and Short Circuit.** All circuits shall be tested to determine that they are continuous and free from short circuits.

**634.03.2.2--Freedom from Unspecified Grounds.** All circuits shall be tested to see that they are free from unauthorized grounds.

**634.03.2.3--Resistance to Ground.** All non-grounded conductors shall be tested with a 1000 volt DC megger. The insulation resistance shall be a minimum of 10 megohms.

**634.03.2.4--Ground Resistance.** The resistance to ground shall not be more than 25 ohms. The above tests shall be in addition to specified tests required for the individual items.

**634.03.3--Satisfactory Performance Period.** After satisfactory completion of the above tests, the traffic signal installation shall be placed in operation. Final acceptance will not be made until each traffic signal installation has operated satisfactorily for at least 30 consecutive days. During each 30 day performance period, if failure should occur in any of the mechanical or electrical equipment in the system other than minor readily replaceable components such as light bulbs, etc., the cause for the failure shall be determined, the necessary replacements made, and the system operated satisfactorily for an additional 30 consecutive

days. Contract time will continue to be evaluated during the satisfactory performance period(s).

When the Contractor has satisfactorily completed all items of work on the project including the satisfactory performance period, the Engineer will make a final inspection of the completed work in accordance with Subsection 105.16.2. If the completed work is found to be satisfactory, the Director will release the Contractor from maintenance.

Final acceptance is also subject to the guaranty provisions of Subsections 106.01, 634.02.4 and other provisions of the contract.

**634.03.4--Training Period.** Except as provided in the following paragraph, the Contractor shall provide training on the control equipment to be installed within the scope of this contract. All training shall be conducted by the Contractor at no addition cost to the State. The Contractor shall provide a total of 20 hours of operational and maintenance training.

If, in the opinion of the Engineer the training period for the particular equipment to be supplied is not necessary, then the requirement of a training period will be waived.

**634.03.4.1--General Requirements.** Training in system and equipment operation will be provided for State or local agency engineering personnel. Maintenance training for the intersection control equipment will be provided for State or local agency maintenance personnel. The training of instructors and preparation and furnishing of supplemental text material and training aids shall be the responsibility of the supplier. All training shall take place in facilities provided by the Contractor and approved by the Engineer. The Contractor shall be responsible for providing the training. The training shall be conducted by personnel of the Contractor or the equipment supplier or manufacturer.

**634.03.4.2--Scope of Training.**

**634.03.4.2.1--Operation Training.** The objective of this training program is to provide engineering and management familiarization with the operation of the traffic control system and to provide a capability for proper implementation and use of the system. The instruction shall include, but shall not be limited to, system theory and general equipment operation.

**634.03.4.2.2--Maintenance Training.** The objective of this training is to familiarize the maintenance personnel with the technical operation, maintenance procedures, and trouble-shooting procedures for the installed equipment. The instruction shall include, but shall not be limited to, maintenance procedures and operation covering intersection controllers.

**634.03.4.2.3--Scheduling of Training.** Scheduling of training sessions shall be coordinated with the Engineer. Operation training and maintenance training shall not be scheduled concurrently.

**634.03.4.2.4--Personnel to be Trained.** The Contractor shall be prepared to provide training for personnel appointed by the Engineer.

## **SECTION 635 - VEHICLE LOOP ASSEMBLIES**

**635.01--Description.** This work consists of furnishing all component materials required to form complete independent vehicle loop assemblies of the types specified and assembling, constructing, erecting, and installing same in conformity with these specifications to insure properly operating units in accordance with the designs and at the locations shown on the plans or as directed.

**635.02--Materials.** Materials used in this construction shall conform to the requirements of Subsection 722.18.

### **635.03--Construction Requirements.**

**635.03.1--Loop Slots.** Loop wire shall be installed in saw cuts in the roadway made by a diamond or abrasive power saw. The slot width and depth shall be as indicated on the plans; however, in all cases the slot shall be of sufficient depth to provide for a minimum of one inch cover between the top of the loop wires and the roadway surface.

The saw cuts shall be overlapped so that the slot has full depth at all corners. All corners where loop wires turn shall be diagonally cut so that there are no jagged edges or protrusions which may damage the wire.

Prior to installation of the wire, the saw cuts shall be cleaned and dried. There shall be no cutting dust, grit, oil, free water or other contaminants in the saw cut.

**635.03.2--Wire Installation.** The loop wire shall not have any cuts, nicks, abrasions or breaks in the insulation before or after installation in the slot. Any wire having defects in the insulation shall be replaced.

Loop wire and lead-in to the pull box or loop detector shall be one continuous length of wire with no splices.

Loop lead-in from the curb or edge of pavement to the pull box shall be installed in conduit of the size and type as indicated on the plans. The loop lead-in for each loop shall be run in separate saw cuts from the loop to the pull box.

The two loop lead-in wires shall be twisted two to five turns per foot from the

loop to the point of termination.

Loop lead-in wires or shielded cable terminating in controller cabinets, detector cabinets or pull boxes shall be uniquely identified by an insulated, waterproof tag. Identification shall indicate the lane and the direction of traffic it detects.

Lead-in as intended in this section is the two loop wires from the loop to the shielded cable.

Each loop shall have a shielded cable from the pull box to the controller cabinet or detector equipment box, unless otherwise specified and/or directed by the Engineer. There shall be no splices in the shielded cable unless otherwise directed by the Engineer or shown on the plans. Shielded cable shall be as specified in Section 636.

The wire shall be placed in the bottom of the slot so that there are no kinks, curls, straining or stretching of the insulation. Subsequent turns of the loop shall be placed to assure vertical stacking of the wires.

Special care shall be taken in seating the wires so that the insulation will not be broken or abraded. No sharp tools such as screwdriver or metal object shall be used for this operation.

Loops shall have sufficient turns of loop wire to conform to the following tables unless the manufacturer of the loop detector being used specifically recommends different inductance values. Loop location and configuration shall be as shown on the plans unless otherwise directed.



**LOOP INDUCTANCE TABLE**  
**6-Foot Loop Width**

Loop Size feet	Inductance, microhenries			
	1 Turn	2 Turn	3 Turn	4 Turn
6 x 4	8	25	56	100
6 x 6	10	31	70	124
6 x 10	14	43	96	171
6 x 15	19	58	129	229
6 x 20	24	72	161	286
6 x 25	29	87	194	
6 x 30	34	101	226	
6 x 35	38	116	259	
6 x 40	43	130		
6 x 45	48	145		
6 x 50	53	159		
6 x 55	58	173		
6 x 60	63	188		
6 x 65	67	202		
6 x 70	72	217		
6 x 75	77	231		
6 x 80	82	246		
6 x 85	87	260		
6 x 90	91	275		
6 x 95	96	289		
6 x 100	101	303		

**LEAD-IN VS. LENGTH INDUCTANCE**

Length Feet	Inductance microhenries
50	14
100	26
150	38
200	50
250	62
300	74
350	85
400	97
450	109
500	121
550	133
600	145
650	158
700	171
750	184

Total Inductance, loop and lead-in inductance, shall be from 135 to 500 microhenries.

After placing the wire in the slot it shall be rechecked for slack, raised portions and/or tightness and to assure that the wires are depressed to the bottom of the slot.

**635.03.3--Sealing the Saw Cut.** All saw cuts with the wire installed shall be inspected and approved by the Engineer before the sealer is installed.

The Contractor shall install the sealer in strict adherence to the manufacturers recommendation and these specifications.

No sealer shall be installed during inclement weather or under any condition which might introduce moisture into the saw slots.

The viscosity of the sealer shall be such that it can be readily poured into the slot, completely surround the wires, displace all air and fill the slot so that the sealer is flush with the roadway surface. The finished sealed slot shall be waterproof and present a neat workmanlike appearance.

The sealer shall be sufficiently hardened before allowing traffic on it.

**635.03.4--Testing.** After the loop and lead-in have been assembled in place and before sealing the saw slot, a continuity check and a resistance check on the loop to ground shall be made. Resistance to ground shall be not less than 10 megohms. This same test shall be made after the slot is sealed. An inductance test shall also be made to insure that the required inductance values are achieved.

**635.04--Method of Measurement.** Vehicle loop assembly will be measured by the linear foot computed horizontally along the saw slot in which the loop wire is installed and will not include the loop lead-in to the pull box.

Probe point detection unit will be measured as paired units per each which measurement shall include all items necessary to complete the installation.

**635.05--Basis of Payment.** Vehicle loop assembly & probe point detection unit, measured as provided above, will be paid for at the contract unit price per linear foot of loop or per each paired probe point detection unit, which price shall be full compensation for furnishing all materials; for all drilling and/or sawing; installing; sealing; connecting lead-in; testing; and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

- |   |                   |
|---|-------------------|
| 635-A: Vehicle Loop Assembly              | - per linear foot |
| 635-B: Probe Point Detection Unit, Paired | - per each        |

**SECTION 636 - SHIELDED CABLE**

**636.01--Description.** This work consists of furnishing and installing shielded cable from the two wire loop lead-in to the detector amplifier at the locations as shown on the plans or as directed.

**636.02--Materials.** Materials used in this construction shall conform to the following requirements.

**636.02.1--Shielded Cable.** Shielded cable shall conform to the requirements of loop detector lead-in cable in Subsection 722.03.

**636.02.2--Conduit.** Conduit required for installation of the shielded cable shall be in accordance with Section 668.

**636.03--Construction Requirements.**

**636.03.1--Construction Details.** Shielded cable from the loop lead-in to the detector amplifier shall be of one continuous length and installed in conduit or aerially supported on messenger cable and spliced to the loop lead-in wires in the pull boxes.

All splices in pull boxes must be carefully made to insure constant low resistance and must be insulated by means of a waterproof splice. The loop lead-in shall be spliced to the shielded cable using butt splice crimp connectors. The connectors should then be coated with a waterproof adhesive. Each splice should then be separately wrapped with an all weather electrical tape and a self bonding electrical tape. Finally, both splices should be wrapped together with an all weather electric tape and coated with a waterproof adhesive.

Shielded cable shall be solidly fastened with ring lugs to the terminal strip in the detector equipment cabinet or controller cabinet. Both ends of the shielded drain wire shall be cut off flush and waterproofed so as to not come in contact with the pull box or ground.

All work performed shall present a neat and workmanlike appearance.

Installation of shielded cable in conduit or aerial shall comply with applicable provisions of Section 666.

**636.03.2--Tests.** After installing shielded cable lead-in and connecting to loop lead-in the same tests as required under Subsection 635.03.4 shall be performed.

**636.04--Method of Measurement.** Shielded cable will be measured by the linear foot. The measurement shall be computed horizontally along the conduit or aerially along the messenger cable in or on which the shielded cable is

installed. No extra length will be allowed for risers to equipment cabinets, controller cabinets or messenger cable. The points for the measurement of length will be considered specifically as the center of the pull boxes, equipment or controller cabinets, or messenger cable support structure.

**636.05--Basis of Payment.** Shielded cable, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all materials, for all installing, connecting and testing, and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

636-A: Shielded Cable \* - per linear foot

- \* For shielded cable other than AWG #14, 2-conductor, the pay item will indicate the AWG and/or number of conductors.

## SECTION 637 - EQUIPMENT CABINETS

**637.01--Description.** This work consists of furnishing and installing equipment cabinets of the type and at the locations shown on the plans, or as required, all in accordance with the requirements of these specifications and the design details shown on the plans.

**637.02--Materials.** Materials shall meet the requirements of Subsection 722.13.

**637.03--Construction Requirements.** The installation as a whole shall be carried out in conformance with the requirements of these specifications and as shown on the plans, or as directed and shall present a neat and workmanlike appearance. Safe construction and installation practices, meeting the requirements of the N.E.C. and local requirements shall be maintained.

**637.04--Method of Measurement.** Equipment cabinet at each required location will be measured as unit quantities per each. Such measurement shall include all items necessary to complete the installation.

**637.05--Basis of Payment.** Equipment cabinet, measured as provided above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for all construction, erecting, installing, connection; for mounting attachments, shelves, lock keys, breathers, drains, ground wire, terminal strips, surge protection, circuit breakers, and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

## **SECTION 638 - LOOP DETECTOR AMPLIFIERS**

**638.01--Description.** This work consists of furnishing loop detector amplifier units complete with all equipment necessary for installation in the detector equipment box or controller and connection to the loop shielded cable lead-in and detector supply cable.

When specified, this work shall also consist of furnishing infrared vehicle detector units with all equipment necessary for installation for side of pole mounting and connection to signal cable.

**638.02--Materials.** Loop detector amplifiers shall meet the requirements of Subsection 722.19.

Infrared vehicle detectors shall meet the requirements of Subsection 722.20.

### **638.03--Construction Requirements.**

**638.03.1--Construction Details.** The installation of each loop detector amplifier unit shall consist of mounting in the cabinet and connecting to input and output cable as indicated on the plans and/or in these specifications or as directed and shall present a neat and workmanlike appearance.

Infrared vehicle detector units shall be side-of-pole mounted in such a manner to align infrared output to position shown on plans.

**638.03.2--Tests.** The Contractor shall demonstrate to the Engineer's satisfaction the operation of the detector amplifier in all modes.

**638.04--Method of Measurement.** Loop detector amplifier and infrared vehicle detector will be measured as unit quantities. Such measurement shall include all items necessary to complete the installation.

**638.05--Basis of Payment.** Loop detector amplifier and infrared vehicle detector, measured as provided above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for all construction, erecting, installing, connecting, testing, and for all equipment, tools, labor, and incidentals necessary to complete the work.

Payment will be made under:

638-A: Loop Detector Amplifier, \_\_\_\_ Channel  
or

Loop Detector Amplifier, Card Rack Mounted \_\_\_\_ Channel - per each

638-B: Infrared Vehicle Detector, Width of Lens - per each

## SECTION 639 - TRAFFIC SIGNAL EQUIPMENT POLES

**639.01--Description.** This work consists of furnishing all component materials required to form completed independent signal equipment poles and extensions of the types specified and assembling, constructing, erecting and installing same in conformity with these specifications to ensure support poles in accordance with the design(s) and at the lines and grades shown on the plans or as directed.

**639.02--Materials.** The materials used in this construction shall conform with the general requirements of these specifications and the specific requirements set out hereunder.

**639.02.1--Poles.** Poles shall meet the requirements of Subsection 722.02.

**639.02.2--Mast Arms.** Mast arms shall be steel meeting the requirements of Subsection 722.16.

**639.02.3--Foundations.** Cast-in-place foundations for concrete, steel, and/or aluminum shafts shall be as specified on plans, and shall be cast of reinforced Class "B" Concrete conforming to the requirements of Sections 601 and 602. Anchor bolts, washers, and hexagon bolts for use in the foundation shall conform to Subsections 722.11 and 722.12. The anchor bolt shall be galvanized only through the threaded section and a minimum of six inches below the top of the concrete foundation. The foundation bolts shall be set in the concrete foundation to fit the bolt circle of each type of pole. Conduit for electric cable shall comply with the requirements for such materials as set out in Subsection 722.05.

**639.02.4--Shaft Extension.** The traffic signal equipment pole shaft extension shall meet the requirements of the plan.

### **639.03--Construction Requirements.**

**639.03.1--Foundations.** Excavation for concrete foundations or butts shall be opened vertically in accordance with the methods of Section 206 with a tolerance of plus two inches from neat lines and grades as shown on the plans or required by local conditions. Adjacent earth shall be compacted sufficiently to withstand the loadings set out under Subsection 722.02.1.3. Before placing concrete, the Contractor shall place reinforcing bars, conduit and anchor bolts, all in accordance with plan details, and held rigidly in place by approved methods. Concrete foundations shall be formed, cast and cured in accordance with the provisions of Section 601. The top surface shall be finished smooth, and sloped

to drain.

**639.03.2--Setting and Aligning Poles.** Poles anchored to the concrete foundation or with precast butts shall have sufficient rake so as to assume a vertical position when the load is applied. Poles with precast butt shall be wet-tamped in place with crushed aggregate, concrete or satisfactory cement stabilized soil, as directed. Poles set on concrete foundations may use leveling nuts to align poles. After alignment of pole on the concrete foundation is completed, the entire area between the bottom of the pole and the top of the concrete foundation shall be filled with grout meeting the requirements of Subsection 714.11. Careful aligning of the poles shall be considered a most essential feature of the installation of the assembly and shall be as nearly perfect as practicable.

**639.04--Method of Measurement.** Traffic signal equipment pole of the type specified will be measured as unit quantities per each. Such measurement shall include foundation, mast arms and all other incidentals necessary to complete the work.

Traffic signal equipment pole shaft extension of the type specified will be measured as a unit quantity per each. Such measurements shall include the pole attachment, shaft, and all other mounting attachments necessary to extend a shaft as required in the plans.

**639.05--Basis of Payment.** Traffic signal equipment pole and traffic signal equipment pole shaft extension of the type specified, measured as provided in above, will be paid for at the contract unit price per each and pole extension, which price shall be full compensation for furnishing all materials, for excavating, backfilling, replacing sod, and for all constructing, placing, curing, erecting, installing, connecting and testing; for foundations, poles, pole bases, mast arms, caps, covers, ground wire, ground rods, hardware and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

639-A: Traffic Signal Equipment Pole, Type \_\_\_\_\_ - per each

639-B: Traffic Signal Equipment Pole Shaft Extension, Description - per each

**SECTION 640 - TRAFFIC SIGNAL HEADS**

**640.01--Description.** This work consists of furnishing traffic signal heads of the type specified and installing them in accordance with these specifications and the details shown on the plans or as directed.

**640.02--Materials.** Materials furnished for traffic signal head installation shall conform to the requirements of Subsection 722.14.

**640.03--Construction Requirements.**

**640.03.1--Construction Details.** Traffic signal heads shall be mounted on the messenger cable, mast arms, or pedestal poles and connected to the signal supply cable as indicated on the plans and as required in these specifications.

Initial location and aligning of heads shall be performed as indicated on plans. Final positioning and aligning shall be performed by field observation to obtain optimum visibility of the signal faces by approach traffic.

Ample slack shall be left in the signal supply cable to provide for field adjustment of head alignment and to form drip loops after heads are in final position.

The new signal heads shall hang over the traffic lanes for no more than two weeks before the traffic signal installation is turned on. During this time the heads shall be completely covered to the satisfaction of the Engineer so as to not conflict with the existing signal heads or be a distraction to the motorists.

**640.04--Method of Measurement.** Traffic signal head of the types specified on the plans will be measured as a unit quantity per each, such measurement being inclusive of the housing, mounting attachments, lens, lamps, reflectors, visors, sockets, socket wiring, back plates where specified, turn-signal signs, tether cable, and other necessary incidentals and being inclusive of all materials, work and services necessary for a properly constructed, tested and operable unit complete in place and accepted.

**640.05--Basis of Payment.** Traffic signal head of the types specified, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing housing, mounting attachments, lens, lamps, reflectors, visors, sockets, socket wiring, back plates where specified, turn-signal signs, tether cable, and all other materials; for installing, mounting, connecting, aligning, testing, and for all equipment, labor, tools, and incidentals necessary to complete the work.

Payment will be made under:

640-A: Traffic Signal Head, Type \_\_\_\_\_ - per each



## **SECTION 642 - SOLID STATE TRAFFIC ACTUATED CONTROLLERS**

**642.01--Description.** This work consists of furnishing all component materials required to form complete and independent solid state traffic actuated controller unit(s) of the type(s) specified and assembling, constructing, erecting, and installing same in conformity with these specifications, to insure properly operating unit(s) in accordance with the design(s) and at the locations, lines and grades shown on the plans or directed.

### **642.02--Materials.**

**642.02.1--Controller Units.** The purpose of this subsection is to describe the minimum acceptable design and operating requirements for a solid state two to eight phase traffic signal controller that utilizes digital concepts for all interval settings and timing.

All definitions shall be in accordance with NEMA Standards Publication TS 1-1989 Section 1.

Programming of controller unit variables shall be by way of a front panel keyboard and display. The controller unit shall prevent the alteration of the keyboard set variables. The controller shall use English language menus.

The units shall be shipped with a universal "Access" code. This code shall also be user programmable via the keyboard.

All variables and variable names shall be displayed for visual verification at the time of data entry.

The controller unit shall maintain user programmable variables in EEPROM memory to assure continued safe and efficient controller unit operation in the event of power loss. No batteries are required except for models with coordination and time base clocks which utilize RAM for continuous clock operation.

The controller unit shall perform all of its functions within the environmental conditions specified in NEMA Standards TS 1-1989 Section 2.

Input-output interface of the controller shall meet the following requirements:

- (1) The electrical limits of inputs and outputs shall meet the requirements of NEMA Standards TS 1-1989 Section 13.2.
- (2) Input functions and number of terminals shall meet the requirements of NEMA Standard TS 1-1989 Section 13.3.

- (3) Output functions and number of terminals shall meet the requirements of NEMA Standards TS 1-1989 Section 13.4.
- (4) Connectors and connections shall conform to NEMA Standard TS 1-1989 Section 13.5.
- (5) An RS-232C interface and connector shall be provided for interconnecting to a printer, another like controller unit, a local personal computer, or a remote personal computer through an external modem.

The controller unit shall be capable of transmitting ASCII coded information (data, letters, headings, etc.) to an 80 column or larger printer. The printer must be RS232C compatible, be able to receive ASCII coded serial data at 1200 baud, eight data bits and odd parity.

The controller unit timing and operational data shall be individually transmitted to the printer. The printout shall be in a format easily understood by a person familiar with traffic engineering terminology. The unit to printer transmissions shall not interrupt normal controller unit operation.

The controller unit timing and operational data shall be individually transmitted to/from another like controller unit.

The controller unit timing and operational data shall be individually transmitted to/from a personal computer running the appropriate software.

The controller unit active status, e.g. Traffic Timers, Coord Timers, Preempt Timers, and Time Base Current, shall be individually transmitted to the personal computer running the appropriate software.

The controller unit report logs shall be individually transmitted to the personal computer running the appropriate software.

The controller unit shall allow the user access from a remote personal computer and also from a local laptop personal computer. The user shall be able to communicate with the intersection controller, as described, in order to monitor current operation; record and analyze traffic conditions by time and pattern; and modify, upload and download any controller program or timing parameter.

Provision for a separate communications port shall be made for purposes of using the controller in a system's environment. In the event the controller is used as a "system controller", no changes to the controller shall be allowed, other than the addition of an internal communications module (modem board), and the unit shall not require re-programming of timing data.

All controllers shall be modular and completely solid state in function. Gears,

cam shafts, motors, reed switches, etc., shall not be used for any functions within the controller.

Timing shall be digital; analog timing is prohibited.

It shall not be permissible to connect two controllers together for the purpose of increasing their control capacity. Special equipment not specifically covered by this specification shall be electronic and solid state in construction.

The power supply shall be easily removable from the main frame with the use of only common tools. The power supply shall have overvoltage and overcurrent protection for all DC plus and DC minus voltages. The power supply shall be readily accessible.

All controllers shall be provided with frames fully wired for maximum expansibility capable of operating up to eight (8) phases.

The controller frame shall be of sturdy construction and shall be equipped with card guides and edge card connectors to receive the various plug-in modules. A minimum of two card guides, one for the top and one for the bottom, per module slot shall be furnished with the frame. The modules shall be interconnected by means of a motherboard assembly or other approved method.

Modules shall be positively fastened to the frame and shall require no tools to remove or replace. Each module which has a front panel shall be removable and replaceable without the necessity of removing adjacent modules. Controllers with module mounted subpanels shall be provided with blank subpanels for all unused module positions.

Input-output connections shall be considered as part of the controller frame.

The controller frame shall include all modules that are required to make the controller assembly operate as per these specifications. All controller modules supplied shall provide the design maximum complement of circuits. Partially completed modules will not be accepted.

The controller frame shall be furnished completely enclosed in a durable sheet aluminum, or approved alternate, housing with a durable finish. The housing shall be designed to adequately dissipate the heat generated by the controller circuitry. The controller frame shall have the serial number permanently stamped, engraved or printed on the outside of the housing.

The design of the controller unit shall be such that electronic components are logically grouped and arranged on plug-in modules or printed circuit assemblies.

The printed circuit boards shall be constructed in accordance with TS 1-1989

Section 14.2.3. The identification of the component parts shall be etched or silkscreened on the circuit boards.

The controller shall provide the proper intervals and interval sequences as required in the specifications and as shown on the plans. The controller shall be able to skip any traffic phase for which a vehicle or pedestrian call does not exist.

The controller shall provide for the setting of each interval, portion of interval or function by means of pushbuttons. The controller shall be calibrated in seconds and tenths of seconds. Setting of timing and function values shall be accomplished without use of special tools or wiring changes.

There shall be provisions for position indication of all parameters. Display shall be self-evident to permit verification of stored information. Steps required to use pushbutton timing controls shall follow a natural sequence, misleading information shall not be displayed at any time. Controls shall be labeled and completely identified as to what their function and use is.

The interval and function controls shall be located on the front of the controller and shall be properly designated as to the function each control performs.

The required intervals, portions of intervals, and functions for each phase of operation shall be as listed in the table below:

<u>Interval (Function)</u>	<u>Minimum Range in Seconds</u>	<u>Increment in Seconds</u>
Minimum, Initial	0 - 99	1
Extension, Passage	0 - 9.9	0.1
Maximum	0 - 99	1
Maximum 2	0 - 99	1
Yellow Clearance	0 - 9.9	0.1
Red Clearance	0 - 9.9	0.1
Walk	0 - 99	1
Pedestrian Clearance	0 - 99	1
Added Initial	0 - 9.9	0.1
	per actuation	
Maximum Initial	0 - 99	1
Minimum Gap	0 - 9.9	0.1
Time to Reduce	0 - 99	1
Time Before Reduction	0 - 99	1

In addition to the time settings and functions listed and the functions required in NEMA Standards TS 1 - 1985 Section 14.3.2, the following functions shall be provided:

- (1) Per phase response to NA 1 and NA 2 inputs.
- (2) A per phase vehicle call
- (3) A per phase pedestrian call

Functions and indications required on a per ring basis shall conform to NEMA Standards TS 1-1989 Section 14.3.3.

Functions and indications required on a per unit basis shall conform to NEMA Standards TS 1-1989 Section 14.3.4. In addition, the following per unit functions shall be provided:

- (1) Start-up Flash - An adjustable time period of 0 to 99 seconds shall be provided for flashing operation prior to the initialization routine.
- (2) Remote Flash - An input shall be provided to call for remote flash. Upon activation of the input the controller shall service all waiting calls before proceeding to the flash entry phases. After servicing these phases, the controller shall begin flashing operation.

The priority of input functions shall be in the following order:

- |                      |                           |
|----------------------|---------------------------|
| (1) Power up         | (7) Remote flash          |
| (2) External start   | (8) Manual control enable |
| (3) Phase omit       | (9) Ring force off        |
| (4) Pedestrian omit  | (10) Phase hold           |
| (5) Interval advance | (11) Pedestrian recycle   |
| (6) Stop Time        |                           |

The controller unit displays shall be easy to read LCD that operates within the temperature ranges of the NEMA Standards TS 1-1989 Section 2.

The controller unit shall utilize multi-segment alpha/numeric characters for displaying programming information and controller timing. The display shall be clearly readable in ambient light including the cabinet light or full sunlight from a distance of four feet at a 45 degree angle.

The display shall have two modes of operation. The first mode shall be a dynamic mode, it shall show the current timing interval and the time remaining in that interval. The second mode shall be a program mode, it shall show the interval and time/date programmed and/or being programmed.

The unit shall provide the ability to simultaneously display the variable and its value for all applicable entries, i.e., all eight phases of passage time. The following per phase indicators shall be provided:

- |                           |                                 |
|---------------------------|---------------------------------|
| (1) Phase on              | (5) Phase Red, Yellow, Green,   |
| (2) Phase next            | Walk, and Don't Walk            |
| (3) Phase vehicle call    | (6) Number of cars waiting      |
| (4) Phase pedestrian call | (7) Vehicle & pedestrian recall |

Per ring function indications shall be provided as follows:

- |                 |                            |
|-----------------|----------------------------|
| (1) Walk        | (11) Red Rest              |
| (2) Don't walk  | (12) Added Initial         |
| (3) Min. Green  | (13) Time Before Reduction |
| (4) Passage     | (14) Time to Reduce        |
| (5) Max. Out    | (15) Max 1                 |
| (6) Gap Out     | (16) Max 2                 |
| (7) Force off   | (17) Green dwell           |
| (8) Green dwell | (18) Stop Time             |
| (9) Yellow      | (19) Hold                  |
| (10) Red Clear  |                            |

In addition to the features required in NEMA Standards 1-1983, the following per phase features shall be provided:

- (1) Cars before reduction
- (2) Actuated rest-in-walk
- (3) Soft vehicle recall
- (4) Selective phase omit
- (5) Phase detector modifiers for stretch, delay and/or detector switching.

The following per unit features shall be provided:

- (1) Entry and exit phases for remote flash
- (2) Provides print out and unit to unit transfer

The controller unit shall contain a reserve data base of controller unit variables stored in Programmable Read Only Memory (PROM). It shall be possible for the operator to activate the reserve data base by loading it into memory through a simple procedure utilizing front panel controls only.

**642.02.2--Load Switches and Flashers.** The controller and cabinet assembly shall be provided with the number of external load switches required to provide the sequence called for on the plans.

The load switch sockets shall be wired for triple-signal load switches conforming to Section 5 of NEMA Standards Publication Number TS 1-1989. All load switch driver outputs coming out of the controller unit shall be on separate terminal points from the respective inputs to the load switches. These separate points shall be bussed for normal operation. All load switch outputs which may

be programmed for flashing or programmed for monitor connection shall be on separate terminal points from the respective inputs to the flash transfer relays or monitor inputs. These separate points shall be bussed for normal operation.

The flasher socket shall be wired for a Type 3 solid state flasher conforming to Section 8 of NEMA Standards Publication Number TS 1-1989. Flashing of main street load switch output indications shall be placed on one circuit and flashing for minor street load switch output indications shall be placed on the other circuit. It shall be possible to flash either the amber or red indication on any load switch outputs. It shall be possible to easily change the flash indication from the front side of the panel using simple tools without the need to unsolder or resolder connections.

Load switch and flasher bases shall be so designed and constructed as to receive all such devices which may be manufactured to the maximum size requirements permitted under the NEMA Standard Publication Number TS 1-1989.

All support(s) shall be provided so that, as a minimum, it is supporting the flasher and load switch of the maximum size at some point(s) between three inches and seven inches from the panel surface.

At least 90% of the area beneath the load switch or flasher shall be open to allow for free flow of air across the load switches or flasher. There shall be no obstruction within one inch above or below the units within the open area.

**642.02.3--Conflict Monitor.** The controller assembly shall be provided with a conflict monitor which shall cause the signals to go into flashing operation should a conflict in signal indications be sensed. The stop time input will be applied to the controller whenever the monitor causes the signals to go into flash. The conflict monitor shall conform to NEMA Standards TS 1-1989 Part 6. The conflict monitor provided shall contain the number of input channels necessary to monitor the maximum number of load switches possible in the controller cabinet terminal facilities.

**642.02.4--Coordination/Time Base Program.** Each controller unit shall be equipped with an internal program for coordination and time base control. The coordination shall also accept dial, split, and offset commands from hardware interconnected systems. The coordination program shall provide a minimum of 48 timing plans. Coordination settings and activity shall be monitored by the controller unit display.

Offset transition shall be by one of three methods:

- (1) Shortway transition, or
- (2) Infinite dwell transition, or
- (3) Dwell with interrupt transition

The coordination shall provide smooth transfer from free to coordinated and program to program operation.

The coordinator shall provide for selecting which phase(s) are to be coordinated. The coordinated phase(s) shall operate as non-actuated in the coordinated mode. The controller shall monitor the sync pulse so that it will revert to free operation when no sync pulse is received for three consecutive cycles.

The coordinator shall be capable of manual front panel selection of dial-split-offset combinations. Manual selection shall override interface commands. Manual sync of the pattern shall be controlled through the front panel.

The coordinator shall be capable of free operation. During this mode, all coordinator control of the controller operation will be removed. The coordinator shall recognize input requests that conflict with the internal coordination operation and automatically revert to free mode when the inputs are active. These remote inputs include stop time, manual control enable and preemption.

The internal coordinator shall provide techniques to guarantee that all unused time from the non-coord phase(s) in the background cycle shall be reallocated to the coord phase(s).

The coordinator shall provide for a controlled release (permissive period) to each of the non-coord phases in sequence. When a call is not present for the phase to be serviced next in sequence, the coordinator shall re-allocate that phase's time to the end of the coord phase. The time allocated to any actuated phase shall never exceed that programmed regardless of when it may appear in the background cycle because some other phase gapped out earlier than the limit set in the program.

Prior to the completion of the coord phase time and the beginning of the first permissive period, the coord phase pedestrian shall display the ped clear indication and dwell DONT WALK. This shall eliminate the need to provide ample time in each subsequent phase time for the coord phase ped clear. The coord phase pedestrian shall dwell DONT WALK until such time as the coord phase terminates and returns to green or the last permissive period in the cycle is complete without the coord phase terminating.

The user shall enter the coord phase(s), the phase times, and offsets. All timings shall be in seconds so there shall be no conversion from seconds to percent and vice versa. The yield points, permissive periods, and force off points shall be calculated internally.

The coordinator shall provide an adjustable time (split) for each phase for each of the timing plans. The phase time shall be adjustable from 1 to 99 seconds. For the coord phase(s) this shall become the minimum phase time and for the



actuated phases it shall become the maximum phase times.

The coordinator shall provide for operation modifiers to be selected for each actuated phases in each of the sixteen timing programs. The five modifiers shall be:

- (1) Minimum Vehicle Recall
- (2) Maximum Vehicle Recall
- (3) Pedestrian Recall
- (4) Maximum Vehicle Recall and Pedestrian Recall
- (5) Phase Omit

The coordinator shall provide a means to select one of the alternate sequences or the standard sequence as a function of the pattern, Dial/Split/Offset, in effect. When the coordinator is running a pattern, the external interface inputs shall not override the pattern sequence.

The coordinator shall provide two types of permissive periods. The permissive period shall control the time period during which the coordinator releases the coord phase(s), allowing the controller unit to begin servicing calls on the non-coord phases.

The first type of permissive operation shall consist of a standard vehicle permissive. The length of the period shall be determined by the phase time and the minimum time. Minimum time equals minimum green or maximum initial + vehicle yellow + red clear.

The second type of permissive operation shall consist of a separate pedestrian permissive concurrent with the vehicle permissive. The length of this period shall be determined by the phase time and walk + ped clear + phase yellow + red clear.

When the controller unit yields during any permissive period, the coordinator shall allow the controller unit to service all the subsequent phase(s) in normal order before returning to the coord phase(s) and it shall not yield on subsequent permissive periods in the same cycle.

The internal Time Base Control shall be a special program operating within the controller unit. A minimum of 100 different Time Base Control events shall be capable of being programmed over a 99-year time frame on a Time-of-Day, Day-of-Week, and Month Day-of-Year basis.

Time Base Control events shall be entered through the controller unit front panel or transferred from another like controller unit. Time Base Control settings and activity shall be monitored on the controller unit display.

The Time Base Control program shall output dial, split, and offset commands to the coordination program. It shall be possible to perform functions not necessarily traffic related within the Time Base Control program by programming and using the three auxiliary outputs.

The Time Base Control shall be provided with a line frequency driven clock and backed up by a battery supported crystal controlled clock. During normal operation, the line frequency driven clock shall control all timings and resynch the crystal controlled clock to the line frequency clock once per minute. When power is removed and reapplied, the crystal controlled clock shall provide the current time to the line frequency clock.

A battery backup voltage source shall be provided with the TBC circuitry. In the battery backup mode time shall be maintained to within  $\pm 0.005\%$  as compared to WWV time standard.

The Time Base Control shall provide for daylight savings time to be programmed to occur automatically as defined by law in most states, to occur automatically at any user selected date, or not to occur.

A program day shall be the list of traffic and/or auxiliary events to occur in a 24 hour period. The Time Base Control program shall provide for at least 99 program days to be defined.

It shall be possible to equate program days which may require the same event listing to effectively multiply the event capacity.

It shall be possible to copy an entire program day event listing to another program day to establish a data base for editing to create a similar but different program day event listing.

The exceptions to the normal day-of-week event listings shall utilize Time-of-Year Special program days. Part of the Time-of-Year Special program days shall be utilized for special day programs which occur on the same date (month and month day) every year, and part shall be utilized for special days which occur on one date (year, month, and month day).

The Time Base events shall be implemented from a weekly schedule of program days on a day-of-week (except for special days) basis.

The Time-of-Year event structure shall provide a means of substituting two alternate weekly schedules for the normal weekly schedule.

In addition to dial, split, and offset commands, the Time Base Control program shall provide the following as traffic events:

- (a) Flashing (voltage monitor inactive)
- (b) Free
- (c) Maximum two timing by phase
- (d) Phase omit by phase

Maximum two Timing by Phase and Phase Omit by Phase are Free Mode modifiers and shall not be part of an event which selects a pattern (Dial/Split/Offset) or Flash.

There shall be three auxiliary outputs available. Each output shall be non- cyclic, each totally independent of any other output. The outputs shall not be affected by any other input including the On-Line input. The auxiliary outputs may begin and/or end concurrently with another program.

The coordination programs shall be capable of being selected based on manual (keyboard) inputs, Time Base Control event, and interconnect inputs. Program select priority shall be:

- (a) Manual Inputs
- (b) TBC Events
- (c) Interconnect Inputs

When the TBC On-Line input is active, the TBC events have no priority and program selection shall be based on manual inputs or interconnect inputs.

When the On-Line input is active, the coordination routine reverts to TBC control based on sync monitor failure.

**642.02.5--Preemption.** Internal Preemption shall be a special program operating within the controller unit. The preemption program shall accept commands from at least two preempt inputs and provide the timing and signal display programmed to occur in response to each.

The preemption program shall recognize the current signal display at the time of preempt and shall provide transition timing and signal display to the programmed preempt condition. Two preempt conditions with an intermediate set of clearances shall be capable of being programmed; i.e., Track Clear and Dwell. Once the preempt dwell has been satisfied, the preemption program shall provide an exit transition timing and signal display to the programmed return-to-normal condition.

Preemption parameters shall be entered through the controller unit keyboard or transferred from another like controller unit. Preemption settings and activity shall be capable of being monitored on the controller unit display. Preemption controls shall be internally applied and shall override the standard unit input modifiers.

The preemption program shall provide 13 timing intervals for each preempt routine and one timing interval for each ring in the controller unit. The timing Intervals and Range shall be:

<u>Interval</u>	<u>Range in Seconds</u>
I. Min Grn/Wlk - Ring 1	0 to 99
II. Min Grn/Wlk - Ring 2	0 to 99

The minimum timing intervals per preempt routine shall be as follows:

<u>Interval</u>	<u>Range in Seconds</u>
A. Delay Before Preempt	0 to 99
B. Preempt Duration	0 to 999
1. Selective Ped Clear	0 to 99
2. Selective Yellow Clear	0 to 9.9
3. Selective Red Clear	0 to 9.9
4. Track Green	0 to 99
5. Track Ped Clear	0 to 99
6. Track Yellow Clear	0 to 9.9
7. Track Red Clear	0 to 9.9
8. Dwell (Hold)	0 to 99
9. Return Ped Clear	0 to 99
10. Return Yellow Clear	0 to 9.9
11. Return Red Clear	0 to 9.9
** Exit Phase	Return-to-Normal Display

The preemption program shall provide the signal display for an orderly and safe transition from the point of entry to the first preempt green state (Track Green), from the first to second green state (Track Green to Dwell), and from the second green to the return-to-normal green state (Dwell to Normal).

The controller unit shall be provided with a resident series of diagnostic capabilities describing its own internal state. It shall not require internal access or changes to the controller unit to initiate diagnostic programs.

The controller unit shall perform diagnostics enabling operator verification of proper operation.

The "automatic" diagnostics shall be performed without an operator request. The diagnostics evaluation shall be displayed on the controller unit front panel display.

The controller unit shall contain provisions to monitor the operation of the microprocessor. The monitor shall receive signals at least once every 100 milliseconds from the microprocessor. When the signal is not received for 200

milliseconds  $\pm 20\%$ , the processor monitor shall initiate flashing operation, Voltage Monitor output inactive.

When flashing is initiated as a result of the processor monitor, it shall illuminate a front panel indication labeled "Watchdog". The monitor shall be deactivated when there is a power failure and shall become active when power is restored.

The monitor shall attempt an automatic restart of the microprocessor to the power up Start Flash timing condition. The controller unit shall operate as though power had been removed long enough for a full restart and reapplied. The front panel Watchdog indicator shall remain illuminated until the controller unit front panel has been manually addressed.

The controller unit shall perform diagnostics enabling operator verification of properly operating inputs, outputs, keyboard, and display. The "operator initiated" diagnostics shall be performed only after an operator request through the controller unit front panel.

For all input and output functions, standard and special, the controller shall simultaneously display the state of all functions of a given category so that conditions such as a missed wire or crosstalk errors may be instantaneously demonstrated.

**642.02.6--Alarm Monitoring.** The controller shall monitor and maintain internal logs of the following conditions, as a minimum, including the date and time of occurrence. These logs shall be displayable on the controller unit, printable via the RS232 port and transmitted to an on-street master or personal computer. As a minimum the following event change of status shall be logged:

Cycle Fault	Voltage Monitor	Preempt
Coord Fault	Conflict Flash	Local Free
Coord Failure	Local Flash	Special Status
Cycle Failure	Remote Flash	Power On/Off

A minimum of the last 40 events shall be maintained in the controller unit.

**642.02.7--System Detectors.** The controller shall have the ability to receive input data from up to eight special system detectors in addition to the normal actuated controller unit phase detectors. The user shall have the option to assign any of the phase detectors as "system detectors".

The controller shall process all system detector data, consisting of volume and occupancy, and shall be capable of transmitting the results of this processing to either the on-street master or computer, local or remote. As a minimum, the following parameters shall be determined per system detector:

- raw volume count
- raw occupancy percent
- average volume percent
- average occupancy percent

The controller shall generate a System Detector Report based on an operator determined logging interval and sample period. The report shall include raw volume and occupancy along with averaged volume and occupancy percent for the sample period. This report shall have the capacity to store up to six sample periods. A sample period data set shall remain until the report capacity is exceeded at which time the oldest sample period data set will be replaced by the new data set.

Each detector, both phase and special system, shall be tested by a diagnostics routine for conformance to specified parameters. The detector diagnostics shall monitor activity on each detector for constant calls, absence of calls, and erratic output. These parameters shall be user programmable.

Detectors which have failed the diagnostics and those subsequently operating within diagnostic parameters shall be automatically logged in a Detector Failure Report, including date and time of occurrence. This report shall have the capacity to store up to 20 diagnostic events and the event shall remain until the report capacity is exceeded at which time the oldest event will be deleted and the new event added.

The controller shall provide speed monitoring capability in the form of a Speed Trap function. The controller unit shall provide for up to two independent Speed Traps with operator selectable detector spacings of either 11 or 22 feet, dependent upon the application. Provision shall be made in the controller to monitor the speed in miles per hour. A nominal speed range shall be settable for each pattern, with the percent of vehicles higher, within and lower than this nominal speed range logged for reporting.

A Speed Report shall be provided and shall have the capacity to store up to 12 patterns of Speed data. The pattern Speed data shall remain until the report capacity is exceeded at which time the oldest pattern Speed data shall be deleted and the new added.

The controller shall provide a Communications Report, when used with an on-street master, which will allow the user to view a list of communication failures along with date and time of occurrence. This report shall have a minimum capacity of 20 events (faults). The fault event, including date and time of occurrence, shall remain until the report capacity is exceeded at which time the oldest fault shall be deleted and the new fault event added. This report shall be displayed, printed and transmitted in the same manner as the Alarm Log.

Indication shall be provided on the front panel of the controller unit to denote when a carrier signal is being received, valid data is being received and when the

unit is transmitting.

**642.02.8--Documentation.** Documentation packages shall be delivered for each unit at the same time as the equipment to which it pertains.

The documentation packages shall contain a parts identification that shows the location of every individual component. This includes integrated circuits, transistors, resistors, capacitors, inductors as well as test points, switches and indicators. Parts identification may be imprinted, stamped or etched on circuit boards in lieu of the pictorial layout, provided such markings are in no way obscured from normal viewing as a result of parts mounting and shall be referenced to the schematic.

The documentation packages shall contain a parts replacement guide so that any component needing replacement can be identified. It shall be possible to use the parts replacement guide for information to either find an industry standard replacement part or order a needed component from the manufacturer.

The documentation packages shall include a schematic of each component and printed circuit board to include identification of all parts and terminals.

Data on all ICs shall consist of at least a schematic symbol, a truth table, and identification of pin setting and their functions.

The documentation packages shall include complete electrical and mechanical installation procedure for each type of unit. Procedures shall be precise and easy to understand.

Maintenance and trouble-shooting procedures shall be included and referenced to the schematics so that block checks can be made to locate any defective components. Point to point voltages shall be included that are pertinent to proper servicing. Test points must be easy to locate and contact with test instrument probes.

A complete physical description of the units shall be provided to include at least the physical dimensions of the unit, weight, temperature ratings, voltage requirements, power requirements, material of construction, and complete performance specifications.

A complete set of operation guides and user manuals shall be provided. These documents shall fully cover all programming procedures and programmable options capable of being made to the controllers and associated traffic control equipment. Instructions for modifications within the range of the capabilities of the unit such as changes in phases or sequences and programming matrix boards shall be included.

For each type of controller unit to be supplied, a list of each type of module, subunit, or complete unit contained within the unit or cabinet shall be provided.

If the manufacturer of the equipment enhances the software or other operation systems of the controller unit, coordination program or time base program between the time the project is let and the time it is accepted, the manufacturer shall update the units that have been changed at no additional cost. The units that are in place at final acceptance shall have all of the refinements that have been made up to the date of acceptance.

**642.02.9--Cabinets for Control Equipment.** These cabinets shall be of minimum dimensions and at locations as indicated on the plans.

**Basic Construction** - The controller and all associated equipment shall be provided in a weatherproof metal cabinet of clean-cut design and appearance. All exposed edges shall be free of burns and pit marks.

The cabinets shall be welded steel or aluminum construction meeting the requirements of Subsection 722.13. The cabinet shall have a smooth natural finish. Handles and locks shall be rust proof.

**Welds** - All welds shall be neatly formed and free of cracks, blow holes, and other irregularities. All welds shall be made by the Heliarc welding method. Welds on the exterior faces of the cabinet shall be reduced to a minimum.

All cabinets shall be provided with a hinged, rain tight and dust tight main door which shall encompass at least 80 percent of the full area of the cabinet front. The main cabinet door shall have a number two Corbin lock. Two keys shall be supplied with each cabinet and shall be securely attached to the outside of the cabinet when delivered. A neoprene gasket shall be used to seal the main cabinet door. Hinges shall be made of 14-gauge stainless steel. All cabinets shall be furnished with at least two position door stops which shall hold the main door open at approximately 90 and 180 degrees. The door stops shall be designed to lock into position and withstand the force of a 30-mph wind. A three-point locking system shall be required and shall consist of the following security points:

- (a) Center of cabinet by lock,
- (b) Top of cabinet operated by door handle, and
- (c) Bottom of cabinet operated by door handle.

Security points (b) and (c) shall be designed so that they will remain in the locked position until the main cabinet lock is unlocked. Door handle operation shall be such that the handle is vertical when in the locking position, and the opening motion shall swing the handle away from the location where the key is inserted. The handle shall be capable of being padlocked to prevent opening



when padlocked.

A small hinged, and gasketed "door-in-door" or "police door" shall be included on the outside of the main controller door. The auxiliary door shall not allow access to the controller, its associated equipment, or exposed electrical terminals, but shall allow access to a small "Police" panel. The police door shall encompass the full area of the police panel. The police door shall be equipped with a lock whose key will not unlock the main door. Two keys shall be furnished for each lock and shall be securely attached to the outside of the cabinet when delivered. The police door shall be located in the top half of the main door. The police panel may be either of cast aluminum or sheet aluminum. The police panel shall contain the following:

- (1) Signal-head power switch. When in the OFF position all power to the signal heads shall be removed.
- (2) Flash switch. When in the ON position, the intersection shall flash as shown on the plans. AC power shall be removed from the load switches. Stop timing shall be applied to the controller.

Each cabinet shall contain at least two adjustable shelves to accommodate mounting of the controller and all included auxiliary equipment. The shelves shall permit the controller and/or auxiliary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting operation of the controller. The range of adjustability shall be the full height of the cabinet in maximum increments of two inches. Screws used for mounting shelves or adjustable shelf mounts shall not protrude beyond the outside wall of the cabinet.

The manufacturer's name shall not appear on the outside of the cabinet, but shall appear on the inside of the cabinet door, with the year and month of manufacture. This can be done by a plate welded to the door, or by a moisture resistant label or other approved methods.

In all cases, the cabinet shall be of adequate dimensions to properly house the controller, a coordinating unit if required, and all required appurtenances and auxiliary equipment intended to be contained therein; all in an upright position, with a clearance of at least three inches from the vent fan and filter, to allow for proper air flow. In no case shall more than 70 percent of the cabinet space be used. There shall be at least two inches of clearance on each side of the shelf between the equipment and side walls of the cabinet.

Unless the plans specify pole mounting, the cabinets shall be arranged and equipped for base mounting on a concrete foundation. An anchor bolt template, galvanized anchor bolts, nuts, and hardware as required for base mounting shall be furnished with each cabinet. The Contractor shall caulk around the base of the cabinet and foundation to seal the cabinet and prevent moisture and dirt from

entering the cabinet.

The cabinet shall contain suitably designed, rain-tight vents on the door of the cabinet. Vents shall allow the release of excessive heat and/or any explosive gases which might enter the cabinet. Vents shall have adequate opening area to permit the proper flow of air drawn by the vent fan. The intake vent shall be designed so that no water will be drawn into the cabinet.

The intake and exhaust vents shall be located such as to provide for maximum passage of air around and over the equipment contained therein. A removable dust filter shall be mounted on the inside of the main door completely covering the intake vent. The cabinet air filter shall be of the throw-away type and its minimum area shall be 250 square inches. The filter shall be installed, positioned and firmly held in place so that all intake air is filtered with no by-passing permitted through cracks, clearance spaces or gaps. Positive retainment shall be provided on all sides to prevent warpage of the filter and prevent the entry of foreign matter around the edges. All cabinets shall have a thermostat controlled exhaust fan located at the top of the cabinet. The exhaust fan shall have a minimum rating of 100 CFM. The fan shall be rated for continuous duty and a lifetime of at least three years. A standard fuse of sufficient rating shall be used to protect against surges and short circuits. The thermostat controlling the exhaust fan shall be manually adjustable to turn on between 90°F and 150°F with a differential of not more than 10°F between automatic turn-on and turn-off.

Service switches shall be required for all cabinets. The following toggle switches shall be provided in the cabinet.

- (1) Run-remote-stop time switch. A three-position run-remote-stop time switch can be used to put the controller in stop time manually or by remote input.
- (2) Flash switch. When in the ON position, the intersection shall flash as stipulated on the plans. AC power shall be removed from only the load switches.
- (3) Controller ON-OFF Switch. When in the OFF position, AC power shall be removed from all circuits of the controller assembly and the intersection shall go to flashing operation.
- (4) Detector test pushbutton switch. A detector test pushbutton switch for each vehicle and pedestrian detector circuit shall be provided in a panel on the inside of the front door. The switch and wiring shall place an actuation for the respective vehicle or pedestrian phase when pushed. The switch(es) shall be labeled "Call Switch" and the phase # as well as whether it is vehicle or pedestrian.

A three wire 115-V AC duplex ground fault interrupt (GFI) receptacle shall be mounted and wired in the cabinet. The receptacle shall have a 15-ampere circuit breaker and shall remain in service even when the power switch is turned off. All cabinets shall be provided with a minimum of a 20-watt fluorescent fixture with bulb mounted in the top of the cabinet. A toggle switch shall be provided to turn the light on and off.

The wiring in the cabinets shall conform to applicable requirements of the National Electrical Code (NEC), NEMA and all of the specifications contained herein. All wiring shall be neat and firm. Wires shall be neatly laced into cables with nylon lacing or nylon tie wraps. Cables shall be secured with nylon cable clamps. The controller equipment and terminals shall be so arranged within the cabinet that they will not conflict with the entrance, training, and connection of the incoming conductors, and will be easily traceable and without entanglement. All terminal strips and load switches for field wiring shall be exposed for test purposes or maintenance without removal of the controller or its related equipment. MS connectors and wiring harness for the controller unit, conflict monitor and external logic units shall be furnished and wired into the cabinet. All conductors which are subject to flexing during the opening of cabinet doors, or the removal of equipment shall be stranded with a minimum of 19 strands. All conductors used in the controller cabinet shall be AWG #22 or larger, and shall conform at least to Military Specification: MIL-W-16878D, Type B or D, Vinyl - Nylon jacket, 600 volt, 105°C. Conductors used in controller cabinets shall conform to the following color codes: AC- neutral = white; AC+ line = black; Safety Ground = white w/green stripe. Safety ground is to be electrically isolated from AC- neutral. All wires shall be proper length before assembly. No wire shall be doubled back to take up excessive length. The wire and insulation shall be adequate to handle the current and voltage used in the cabinet. The harnesses shall be neatly arranged and provided with the flexibility for the connectors to reach at least 40 inches from the top of the terminal block panel.

Cabinets for four-phase controllers shall be wired and shall have the necessary logic to provide two vehicle overlaps with capability of being assigned some combination of phases at a future date by the simple addition of wire jumpers.

Electrical connections from the controller and auxiliary devices to outgoing and incoming circuits shall be made in such a manner that the controller and/or auxiliary devices can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires leading therefrom. This shall be accomplished by means of MS connectors and other approved NEMA standard connectors using the NEMA standard pin assignments.

Terminals shall be provided, as a minimum, for the following:

- (a) Terminal with circuit breaker with an internal power line switch for the incoming power line;

- (b) Terminal, unfused, for the neutral side of the incoming power line;
- (c) Terminals and bases for signal load switches and outgoing signal field circuits;
- (d) Terminals and bases for signal flasher and outgoing signal field circuits;
- (e) Terminals for detector cables;
- (f) Terminals for all required auxiliary equipment;
- (g) Terminals for interconnect cable and coordination equipment;
- (h) Terminals for future preemption input lines; and
- (i) Terminals for installation of incoming and outgoing multipair voice grade telephone lines.

Adequate electrical clearance shall be provided between terminal strips. The controller and auxiliary equipment, panel(s), terminals and other accessories shall be so arranged within the cabinet that they will facilitate the entrance and connection of incoming conductors.

Soldering of conductors to terminal lugs may be omitted provided a calibrated ratchet-type crimping tool is used.

All input and output circuit connections to the controller unit, conflict monitor, external logic units, load switches, loop detectors, coordination units, and all other auxiliary equipment shall be made by the use of terminal strips.

Terminal strips shall be provided for connecting the field wires to the output of the load switches. Four terminal strips shall be included in cabinets to permit connecting a minimum of 48 field wires and four terminal strips for connecting a minimum of 48 loop detector wires, which shall include wiring for AC+ and AC-. Terminal strips shall be provided for connecting the controller outputs to the load switches. All terminal strips shall have their connections numbered. A wiring chart shall be provided on the inside of the main cabinet door, to identify the connections of the terminal strips. It shall be completely legible.

The outgoing signal circuits shall be of the same polarity as the line side of the power service; the common return of the same polarity as the grounded side of the power service.

A copper ground buss bar shall be mounted on the back or side of the cabinet wall for the connection of A.C. neutral wires and chassis ground wires. It shall be securely fastened to the cabinet. If more than one ground buss bar is used in a cabinet, a minimum of a No. 10 AWG copper wire shall be used to interconnect them. Each buss bar shall have at least two positions where a No. 6 AWG stranded copper wire can be attached.

All cabinets shall be furnished with a minimum of two circuit breakers having a rating of at least 30 amperes. One circuit breaker shall control the duplex outlet and the service lamp. The other circuit breaker shall control all other electrical

connections.

Each cabinet shall be provided with surge protection as follows:

- (1) AC service input shall be protected by a unit capable of withstanding at least 20 surges of at least 20,000 amperes each. The unit shall have at least three active clamping stages and have internal follow-current limiters. The unit must self-extinguish within 8.5 milliseconds after the trailing edge of the surge. The parallel impedance of the limiters shall be less than 0.15 ohms. The peak clamp voltage shall be 350 volts at 20 kA.
- (2) Each detector input line from a remote detector cabinet or pedestrian push-button shall be protected by a two stage hybrid device capable of withstanding a minimum of 30 surges of at least 5,000 amperes each applied to the input. The device shall have one input lead, one output lead, and a ground lug in order for the signal wire to "pass through" the protector. The voltage across the output must be held to 30 volts when the input is subject to a 2,000-ampere, 10 x 20-microsecond surge. The unit must not interfere with the normal operation of the signal equipment, and must respond in less than 20 nanoseconds.
- (3) The interconnect lines and signal loads shall be protected by a unit capable of withstanding a 10-kA, 8 x 20 nanosecond surge five times without damage. The response time of the unit shall be less than 50 nanoseconds. The maximum clamping voltage shall be no greater than 400 volts at 1 MA. The units must be individually packaged for interconnect line protection and in a package of three for the signal loads.
- (4) The external data communications pair shall be protected at the cabinet entry point by a two stage series hybrid device capable of withstanding a peak surge of 4000 amps, 8 x 20 micro-second wave form. The device shall have a minimum life of 50 surges @ 4000 amps with a response time of less than 20 nano-seconds. The maximum clamping voltages shall be 200V on the incoming telephone line and 15V on the incoming multi-pair voice grade interconnect line.

A radio interference suppressor shall be provided in a series with A.C. power before it is distributed to any equipment inside the cabinet. The filter shall provide a minimum attenuation of 40 decibels, and a frequency range of 200 kilohertz to 60 megahertz. It shall be hermetically sealed in a metal case. The filter shall have the same minimum circuit rating as the main circuit breaker and shall meet the standards of the Underwriter's Laboratories, Incorporated and Electronic Industries Association.

The manufacturer shall provide cabinet noise suppression as required by the particular controller. The thermostat contact and vent fan shall be properly

suppressed.

Each cabinet shall be furnished with three copies of the cabinet wiring diagram and field wiring diagram. These prints shall be full size and completely legible. Where possible, diagrams shall be to a scale picture image of the cabinet layout. Diagrams shall shown the complete wiring of all cabinet components, all switches, terminal board connections, connector connections, fan connections, light fixture connections, flash transfer relays, lightening arrestors, surge protectors, load switch panels, terminals, and any other control functions. Each item shall be clearly identified as to its function.

All components in the cabinet shall be located according to their function and in such manner that they may easily be found on the wiring diagram.

Field wiring and cabinet wiring diagrams shall be designated on the diagrams using the traffic movement designations as shown on the plans. Association of phase numbers with their designated traffic movement shall be clearly indicated on the wiring diagram.

A clear plastic pouch approximately 10 inches x 14 inches with a sliding-lock shall be provided for each controller. The pouch shall not be mounted inside the controller cabinet, but shall be loose for placement inside the controller cabinet.

Foundations. Foundations for traffic actuated controllers shall be constructed of Class "B" concrete meeting the requirements of Section 804, and in accordance with the details shown on the plans.

Anchor bolts for base mounted cabinets shall be 3/4-inch diameter by 16 inches long with a 90 degree bend with a 2-inch leg, overall length of 18 inches. The end opposite the leg shall be threaded for at least three (3) inches with a 3/4 UNC-10 thread. Anchor bolts shall be steel with a hot dipped galvanized or zinc plate surface. Four anchor bolts shall be required for each cabinet.

Traffic Actuated Controller Types. Traffic Actuated Controllers of the following types as shown on the plans and required in these specifications shall be furnished:

- |                   |                   |
|-------------------|-------------------|
| Type 4A - 4 phase | Type 8A - 8 phase |
| Type 4M - 4 phase | Type 8M - 8 phase |

The 'M' Type controllers will be installed in an existing master system. It shall have full upload and download compatibility with the existing master and/or system.

An intersection plan and phasing diagram, including loop designations and detector chart, as noted in the plans, shall be affixed to the door and shall be

completely legible and waterproof.

**642.03--Construction Requirements.**

**642.03.1--Construction Details.** The installation shall be carried out in conformance with the requirements herein stated and shown on the plans, and shall present a neat and workmanlike appearance.

The required cycle lengths, offsets, splits, band widths, and time of day and week each is to occur for each coordinated system will be determined at a later and mutually acceptable (Contractor and Engineer) date after the contract is awarded.

**642.03.2--Tests.** After completion of installation of traffic actuated controllers the Contractor shall demonstrate by tests to the Engineer's satisfaction that (a) all circuits are continuous and free from short circuits, (b) that all circuits are free from unspecified grounds, (c) that the resistance to ground of non-grounded conductors is at least one megohm at 60°F measured with a 1000 ohms per volt megger, and (d) that the ground resistances are not more than 25 ohms.

**642.04--Method of Measurement.** Solid state traffic actuated controller units will be measured as unit quantities per each, such measurement being inclusive of foundation, mounting, cabinet, relays, terminals, circuit breakers, modules, coordination and time base control programs, connectors wiring, overlap equipment and wiring, load switches, controller mechanism and housing and being inclusive of all materials, work, testing and incidentals necessary for a complete and operable unit in place and accepted.

**642.05--Basis of Payment.** Solid state traffic actuated controllers, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract; which price shall be full compensation for foundation construction, for furnishing cabinets, relays, terminals, circuit breakers, modules, coordination and time connectors, overlap equipment, load switches, controller mechanism and housing, mounting material, and all other materials; for constructing, installing, connecting, testing and final cleanup; and for all equipment, labor, tools, and incidentals necessary to complete the work.

Payment will be made under:

642-A: Solid State Traffic Actuated Controllers, Type - per each

**SECTION 643 - CLOSED LOOP ON STREET MASTER SYSTEM**

**643.01--Description.** This specification describes a distributive processing, traffic responsive, control and monitoring "closed loop" system. The system's principal operational task shall be to select and implement traffic signal timing

plans in response to both actual traffic conditions or time based events. To "close" the operational loop, the system shall monitor, in real time, local intersection activity and overall system performance, reporting failures and status conditions both automatically and by operator request. In order to meet current and future traffic control needs, the system shall also provide extensive control monitoring, data collection, reporting and analysis functions.

For complete user flexibility, the system shall provide full access of each local system intersection controller from the remote central-office site. Full access shall include the capability to upload all time settings, operation parameters and status information, as well as the capability to download all time settings and operation parameters. The system shall be designed to capitalize on the cost effective attributes of staged implementation. A building-block design shall be provided which enables future system expansion to occur without major modification to the existing system.

### **643.02--Materials.**

**643.02.1--System Configuration.** The system architecture shall be designed to minimize the effect of equipment failures on system operation and performance. The system consists of four principal elements:

- Local System Intersection Controllers,
- Communication (Telemetry) Links,
- On-Street Master(s),
- Central-Office Computer Software

**643.02.1.1--Local System Intersection Controller.** The local system intersection controller shall be capable of controlling a fully actuated two to eight phase intersection and shall meet or exceed NEMA TS 1-1989 standards for fully actuated traffic control units. The local controller shall have internal communication capability with direct access to the data memory. The local system controller shall be capable of processing controller and detector data and provide all necessary intersection control functions.

The local system intersection control shall meet the requirements of Section 642, Solid State Traffic Actuated Controllers.

**643.02.1.2--Communications (Telemetry) Links.** The communications links for the "closed loop" system shall perform the following functions:

- (a) provide the medium for two-way communications between the on-street master and the local intersection controllers, and
- (b) provide the medium for two-way communication between the on-street master and the central-office computer facility.



Error checking shall be included in both mediums to assure transmission and reception of valid data.

Communications between the on-street master and the local intersection controllers shall require full period connection consisting of either: leased twisted pair designed for full or half duplex operation meeting the requirements of Bell 3002 unconditioned lines, or user owned dedicated hardwire interconnect of copper wire shielded, twisted pair cable. Communications between the on-street master and the central-office computer facility shall be provided by standard touch tone or pulse dial, two-wire dial-up telephone service capable of supporting 1200, 2400, 4800, 9600 and 19,200 baud data transmission. The system shall also provide auto-dial/auto-answer operation with this communications link in order to handle communications originating from either location without operator intervention.

**643.02.1.3--On-Street Master.** The on-street master may be located at an intersection and connected via the communication network to at least 24 local intersection controllers. The master shall be capable of implementing traffic responsive control, time base control, manual control or remote control modes of operation.

Analysis of sampling sensor data from at least 32 system detectors and corresponding selection of the best traffic responsive timing pattern shall be provided by the on-street master during the traffic responsive mode of operation.

Automatic and continuous monitoring of system activity shall be provided by the on-street master to include both master and intersection alarm conditions.

System parameter entry shall be provided via the on-street master including all master and local intersection assignment and group parameters. Master parameters shall include:

- (1) system coordination setup and pattern data entry by group,
- (2) system time base event scheduler,
- (3) system traffic responsive computational and pattern selection setup by group, and
- (4) intersection system group and detector assignments.

The on-street master shall provide comprehensive system report generation including, as a minimum: system, intersection, detector and failure status and history reports in addition to system performance reporting.

An RS-232C interface shall be provided on the on-street master to allow for printing of reports or for interconnecting to a remote central site.

To enhance overall system operation and increase system management

flexibility, the on-street master shall also support two-way dial-up communications to a central-office computer for control, monitoring, data collection and for timing pattern updating purposes, all from a remote central-office location. Continuous, 7 days/week - 24 hours/day, system monitoring shall be enhanced by the on-street master's capability to automatically dial-up the central-office computer upon detection of user defined critical alarm conditions.

**643.02.1.4--Central-Office Computer Facility.** The central-office computer software shall operate with the Departments current operating system or approved equal, and will permit output of status and failure reports, sensor reports and adjustment of parameters for up to 16 on-street master systems from a single site. The central-office computer facility is located in the user's office and shall be connected to the remote on-street master(s) and/or local intersection system controllers via two-way dial-up communications to enable outputs, monitor system operation, and upload/download master and local operational and timing parameters.

For ease of use, distinctive and simplified system parameter and status displays, the software shall provide menu-driven operator interface on a color monitor.

**643.02.1.5--Central-Office Computer Hardware.** The central office hardware shall consist of a microcomputer with a hard disk of at least 80 gigabytes of storage, a 3½" disk drive, two serial ports, one parallel port, a modem, and a CD-R drive for backup. One quad-pack of CD-R disks for backup shall also be included with the system. The central processing unit shall be a 2.8 gigabyte processor with at least one-gigabytes of RAM, or a system of approved equal. The CPU shall support the Departments operating systems.

The hardware shall also include a color monitor and color printer. The monitor shall have a minimum pixel rate of 1024 x 768 and a minimum screen size of 17 inches. The color printer shall have at least 2400 x 1200 color resolution and be capable of printing at least eight (8) color pages per minute.

Internal or external fax/modems capable of auto dial/auto answer operation, compatible with the on-street master and the user's central office computer system shall be provided in the controller cabinet and with the central office hardware. Communications shall be provided by either standard touch tone or pulse dial, over a two-wire dial-up telephone service, supporting 1200, 2400, 4800, 9600 and 19,200 baud rate transmission.

Certification shall be provided by the supplier/manufacture that the modems have met and passed NEMA TS 1-1989 environmental standards for actuated controllers or can verify that units in the field have been operational for over a two year period with no problems attributable to environmental conditions.

**643.02.2--System Functional Requirements.**

**643.02.2.1--Operator Interface.** In order to provide ease in programming and operation, the system shall provide a simplified user-friendly menu format at each local, master and central-office facility. No special programming skills shall be required for the user to fully access and operate this control and monitoring system at any level.

All programming, both of the local intersection controllers and the on-street master(s) shall be via a front panel keyboard and display, driven by English Language menus. All data change entries will be automatically verified against established ranges prior to acceptance to prevent programming data errors. Data access shall be controlled by user definable access controls.

**643.02.2.2--System Traffic Control.** The system shall have the capability of implementing a minimum of four dials, four splits and three offsets for a total of 48 unique timing patterns for each group.

The system shall provide the capability of selecting any of the following operational modes on a group basis:

- (1) Traffic Responsive,
- (2) Time Base (Time-of-Day/Day-of-Week),
- (3) Remote (External Command) and
- (4) Manual (Operator Entry).

The system shall be capable of implementing system Flash and system Free operation. The system shall have the capability to command, on/off based on time, up to eight independent special functions.

**643.02.2.3--Detectors.** The system shall have the capability of accepting and processing data from at least 32 system detectors for traffic responsive program selection.

**643.02.2.4--Pattern Selection.** In addition to providing Manual and Remote program selection capability, the master shall provide for Traffic Responsive and Time Base modes of operation for timing pattern selection.

**643.02.2.4.1--Traffic Responsive Mode.** Traffic plan selection in the traffic responsive mode shall be user enabled. The pattern selection shall be based on sampling detector volume and occupancy analysis by the on-street master. Smoothed volume and occupancy sensor data will be processed at the local system intersection controller, based on a user settable averaging time per system detector, and passed to the on-street master. Any of up to eight detectors at the intersection shall be assignable to each of the functional computation channels in each group, with the channels representing: cycle-selection, directionality (offset), non-arterial flow (split), and special congestion indicators of queue and occupancy.

The operator shall have the option of using either averaged data or highest sensor for each computation function (channel). Additional control shall be provided in the traffic responsive operation mode by allowing the operator to establish the number of failed detectors required to fail the channel. A user selectable weighting factor shall be assignable to each system detector input associated with each channel.

All threshold transition points used to define traffic plan levels will be operator specified and shall be provided with decision points such that one and only one traffic pattern will be selected by the volume and/or occupancy level. In addition there shall be a user-selectable minimum time between plan changes.

**643.02.2.4.2--Time Base Mode.** The system shall provide the capability of implementing time-of-day, day-of-week and week-of-year control for each of the two groups using an internal timeclock referenced to the 60-Hz AC power line frequency for its time base. The Time Base Mode shall contain automatic adjustment for leap year and daylight savings time changes.

The system Time Base Mode shall provide, as a minimum, 100 events each capable of requesting:

- (1) any of the 48 traffic control patterns along with traffic responsive override enable, or
- (2) auxiliary events consisting of enable/disable any of up to four system-wide special functions and setting sample and log interval time periods.

The Time Base Mode of operation shall provide a traffic responsive override which when enabled, the traffic responsive program will override the Time Base program whenever its cycle length is greater than that being commanded by the Time Base. It shall be possible to call for Traffic Responsive control of plan selection from the Time Base Mode.

The system Time Base Mode shall also provide the capability to program special events on a one-time basis for implementing holiday plans or special events up to one year in advance. The capacity for at least 99 special or exception days, as well as a minimum of three alternate week programs shall be available for programming.

All Time Base control commands shall be programmable to a one-minute resolution and shall be configured from events made into day programs which form part of a week program.

The timeclock shall have the capability of maintaining accurate time in the event of a loss of AC power to the clock.

**643.02.2.5--System Control Priority.** The system coordination control

(program-in-effect) for each group shall be selected on a priority basis. The priority from highest to lowest shall be as follows:

- (1) Manual Control Entry
- (2) External Control (Remote Command)
- (3) Time Base Control (Time-of-Day/Day-of-Week)\*
- (4) Traffic Responsive Control.

\* Traffic Responsive control will prevail whenever Traffic Responsive Override Enable is active and the selected cycle length is greater than that being commanded by Time Base.

**643.02.2.6--Measures of Effectiveness.** The system shall have the capability to report selected Measures of Effectiveness (MOE's) on an intersection basis. MOE calculations shall be made on all phases by the local system intersection controller and as a minimum shall include measures such as: Volume, Number of Stops, Delays and Green Utilization. These measures shall be calculated on the basis of the active timing plan. Alternate ways of reporting MOE'S may be approved on a case-by-case review.

**643.02.2.7--Uploading and Downloading.** The system shall provide, for any selected local system intersection controller, the capability of uploading and downloading any or all, new or modified local intersection parameters from the central-office computer and shall include as a minimum all: Phase Timing and Unit Data; Coordination Data; Time Base Data; Preemption Data; System Communication Parameters; System Traffic Responsive Data; and any other System Data residing at the intersection such as Detector Diagnostic Values, Report Parameters and Speed Parameters.

During either uploading or downloading operations normal traffic control operations shall not be suspended. All data shall be continually accessible and may be displayed at the on-street master or the central-office computer.

**643.02.2.8--System Monitoring and Diagnostics.**

**643.02.2.8.1--Monitoring.** The system shall automatically and continually monitor system activity and log/report occurrences of master and intersection alarm conditions. All alarm condition events shall include at the intersection, master and central-office computer, an alpha-numeric description of the event, and the time and date of occurrence.

As a minimum, monitored master alarms conditions shall include:

- (a) insufficient or improper data,
- (b) failed computational channels,
- (c) failed system detectors,

- (d) intersection communication failure,
- (e) failed controllers, and
- (f) at least six special user defined alarms for user application flexibility.

Monitored intersection alarms conditions shall include, as a minimum:

- (a) cycle faults and failures,
- (b) coordination failures,
- (c) voltage monitor,
- (d) conflict, local and remote flash conditions,
- (e) preempt,
- (f) local free, and
- (g) at least six special user defined alarms for additional user flexibility.

When the master detects a critical alarm condition, as defined by the user, it shall automatically dial-up the central-office computer and report the condition. On a busy or no answer the system may be programmed, at user option, to alert a secondary computer.

The system shall also automatically and continually monitor, verify and attempt to correct Sync Pulse, Time Base Clock and Pattern-in-effect.

**643.02.2.8.2--Diagnostics.** The system shall provide capabilities to perform diagnostics on system and local detectors, communications and intersection operations. When a fault has been detected an indication shall be provided. It shall be possible to isolate the fault to the failed unit from controls and indicators available on the master unit. Auxiliary equipment such as a data terminal or CRT shall not be required to identify the failure.

- (a) Sensor Monitoring. Each system and local detector shall be continually verified for proper operation. The local system intersection controller shall maintain a log of all detector failures including date and time of failure and resumption of proper operation. As a minimum, each detector shall be continuously monitored for constant calls, absence of calls, and erratic output.

To prevent program selection based on erroneous detector data, system sensors which fail the monitoring test shall be automatically deleted from volume and occupancy calculations. Upon resumption of satisfactory sensor operation, sensors shall automatically resume input to volume and occupancy calculations. The operator shall be capable of designating the required number of failed system detectors, assigned to a traffic responsive channel, before the channel is classified as failed.

- (b) Communications Monitoring. The master shall provide the capability to diagnose and log failed communications that exhibits no response or

generates invalid feedback. The diagnostics shall enable the user to identify the particular failure and shall provide visual indication of the failure on the master front panel.

- (c) Intersection Diagnostics. Intersection status conditions shall be available for diagnostic display. These diagnostics shall include:

Intersection Status - As a minimum, the master and intersection shall provide for diagnostic display of cycle failure, local free, local flash, conflict monitor flash and voltage monitor flash.

Controller Phase Status - The master shall provide for the real-time display of the controller phase Greens, Yellows and Reds, along with pedestrian WALK and flashing DONT WALK.

Controller Detector Inputs - Provisions shall be made for the real-time display of the intersection detector inputs to the controller on a per-phase basis.

Intersection System Status - The local controller shall provide for real-time diagnostic display of the intersection system operation and identify cycle failure and failure of intersection to display coordinated phase green time at the proper offset.

Controller Inputs/Outputs - In addition to other monitored signals described above, a minimum of six undefined special input functions and eight undefined special output functions shall be provided to be used as desired by the user.

**643.02.2.9--Real Time Display.** The master shall provide for any selected local system intersection controller, real-time status information on it's front panel. Real-time intersection status information shall include simultaneous display of: vehicle and pedestrian signal and detector status by phase, overlap signal status and cars waiting count by phase. Real-time controller status information shall include simultaneous display of: two Ring Active timers; On/Next, Call/Recall and Hold/Omit Status by phase; Coordination, Preempt and Stop Time Status.

**643.02.2.10--System Management.** The system, without hardware changes but with its ability to directly modify master and intersection parameters, shall provide the user system configuration and system operational controls of the following functions: add/delete controllers and system detectors; enable traffic responsive mode; assign intersections to groups; assign system detectors to computational channels and channels to pattern select routines; and assign special and/or standard detectors as system detectors for use with computational channels or to track activity.

**643.02.2.11--System Logging and Reports.** The system shall automatically and continually process system data and log/report on occurrence of changes in the following:

Intersection Status, System Detector Status, Communications Status, Controller Status and Local Detector Status; in addition to System Program Changes, Traffic Responsive Computations, Measures of Effectiveness and Performance.

The reports shall be output via a printer or uploaded to the central-office. The reports shall be obtainable on demand, at the master or central-office, or output automatically at the central-office computer facility at regular intervals as specified by the user.

**643.02.2.12--Security.** The on-street master shall provide for a user specified security code entry before any data may be altered. In order to view any parameter, security code entry shall not be required. Security access shall be automatically rescinded approximately ten minutes after either access was gained or the last parameter change was entered. The master and local controller shall have the ability via keyboard to disable security code requirements, allowing for perpetual access without requiring hardware changes.

Master and local controller access procedures shall be maintained from the central-office computer facility allowing the user full security control of all system components from a remote location.

**643.02.3--Design Characteristics.** The On-Street Master shall be designed to operate in either an office or field environment and shall be suitably housed in a separate enclosure or in a local intersection cabinet. The master shall be designed to meet the following electrical and mechanical requirements:

**643.02.3.1--Programming and Security.** Operator programmable data entry shall be accomplished through panel keyboard(s). The master shall prevent the alteration of keyboard set variables prior to the user having entered a specific access code through the keyboard. The master shall maintain user programmable variables in non-volatile memory a battery-backed RAM to assure continued efficient system operation.

To insure the accuracy of the traffic control parameters, EEPROM technology or battery-backed RAM shall be used to retain all timing and control parameters, even during power outages. Non-critical historical data retention and the Time Base clock shall utilize RAM memory and in the event of power failure, those functions shall be maintained by battery support for a minimum of one year.

**643.02.3.2--Electrical and Environmental.** The on-street master unit shall conform to all applicable portions of the Environmental and Operating Standards



as described in NEMA Standards Publication No. TS 1-1989, Section 2.

**643.02.3.3--Construction.** The on-street master unit shall conform to all applicable portions of the physical requirements as described in the NEMA Standards Publication No. TS 1-1989, Section 14. In addition the master unit shall be designed consistent with maximum commonality between the local intersection controller hardware and shall utilize the absolute minimum number of printed circuit boards, wiring harnesses, ribbon cables and connectors.

**643.02.3.4--Test and Repair.** To enhance maintenance and trouble-shooting activities, on-street masters shall include resident diagnostics as a standard. No extender-cards, special tools or PROMs shall be necessary to fully maintain these components. The master unit design shall insure that all printed circuit boards be readily accessible for maintenance testing purposes. All fuses, connectors and controls shall be accessible from the front of the master unit.

**643.02.4--Central-Office Computer Software.** The central-office computer software shall have the capability to integrate at least 512 intersections into a centrally-monitored system, and shall be able to communicate with at least 16 separate on-street masters through either dial-up telephone service or direct line.

**643.02.4.1--System Monitoring.** All masters, groups within masters, and individual intersections shall be identified and accessed by name to assist the operator in relating actual geographic locations. The name shall be user definable and consist of up to 24 standard ASCII characters. This name shall appear on all displays and reports.

The central-office computer software shall have the capability of monitoring the operation of the master and the performance of any local intersection in the system.

The central-office computer software shall receive system and intersection data from the on-street master(s) and shall tabulate, format and output reports at the central-office site. Alarm conditions, as described in Subsection 643.02.2.8 shall be reported to the central-office computer.

Master status monitoring information shall be available on demand to the central-office computer and shall include, as a minimum:

- (1) group active status which shall report the active operating mode, cycle length, pattern, cycle counter and special functions of each group,
- (2) intersection and detector master status which shall report on the current status of every intersection and system detector, and
- (3) time base master status which shall report on the current status of the Time Base mode of operation.

Local intersection monitoring information shall be available with the central-office computer software and shall include as a minimum, local status conditions of: coordination, preemption, time base and detector functions as well as controller unit status indicating real-time status of all phases and ring timers. Data shall be updated once a second or upon change and shall remain on the display until cancelled by the operator.

#### **643.02.4.2--Remote Real-Time Display.**

On-Street Masters. The central-office computer software shall provide real-time information for any selected on-street master group. These color displays shall include the following status information as requested by the user: Program-in-Effect, Traffic Responsive Program, Special Function Status, Communications Status, Controller Status, System Detector Status, and Local Detector Status.

Local Intersections. The central-office computer software shall provide real-time information for any selected system intersection. The color display shall indicate the real-time operation of the local intersection in geometric representation and shall include:

- Status of all vehicle and pedestrian signals,
- Status of all vehicle and pedestrian detectors,
- Status of all 4 standard overlap signals,
- Status of all hold/omits and recalls,
- All 8 phase and special detector status conditions,
- All coded status and auxiliary output status,
- All preempt input status conditions, and
- Current intersection operational status, including mode and pattern-in-effect.

In addition, real-time color display of local controller unit status shall be provided and shall also include as a minimum an active ring timer status and simultaneous status display of all eight phases.

**643.02.4.3--System Control: Uploading/Downloading.** The central-office computer software shall have the capability of controlling system and/or intersection functions through its ability to download operational and/or timing parameters from a remote central-office site.

**643.02.4.3.1--On-Street Masters.** The central-office computer software shall provide remote timing parameter modifications, for any selected on-street master unit. Remote timing modification shall enable the user to upload master parameters for verification, modification, storage on disk, and/or printout. It shall provide the option of downloading new values to the master. Master parameters shall include as a minimum: Coordination, Traffic Responsive and Time Base parameters as well as Critical Alarm identification and assignment. Normal traffic control operations shall not be suspended during upload/download

activity between the central-office and the on-street master.

**643.02.4.3.2.--Local Intersections.** The central-office computer software shall provide remote timing parameter modifications for any selected local system intersection controller. Remote timing modification shall enable the user to upload local intersection parameters for verification, modification, storage on disk, and/or printout. It shall provide the option of downloading new values to the intersection. Local intersection parameters shall include all data specified in Subsection 643.02.2.7. As from the on-street master, the uploading/downloading operation between the central-office and the local intersection shall not suspend normal traffic control operations.

**643.02.4.4--System Reports.** The central-office computer software shall be capable of receiving system and intersection data from on-street masters and tabulate, format and output reports as described below:

**643.02.4.4.1--Alarms.** Critical operator designated alarm reports indicating local or master operating failures or other serious conditions shall be considered priority reports.

**643.02.4.4.2--Sensor Volume Summary Reports.** The central-office software shall be capable of tabulating, formatting and outputting sensor data from any of the system sensors. This data shall be obtainable on demand or output automatically as specified by the user. The reports shall be output on the color monitor and/or printer as selected by the user.

**643.02.4.4.3--System Status Reports.** The central-office computer software shall provide output reports, generated from data received from the on-street master and local intersection units, indicating system operating status including, but not limited to the following:

- (a) Intersection Status and Online/Offline History,
- (b) System and Local Detector Status,
- (c) Communications Status,
- (d) Controller Status,
- (e) System Program Changes by Group,
- (f) Traffic Responsive Pattern Selections, and
- (g) Performance Analysis, such as Speed and Measures of Effectiveness.

**643.02.4.4.4--Sensor Graph.** The central-office software shall have the capability to plot, in graphical form, detector data for at least eight system detectors by intersection. The graph shall display raw volume, raw occupancy, average percent volume and average percent occupancy along with associated interval time and corresponding raw data multipliers.

Reports shall be output on the color monitor and/or printer as selected by the

user. Any and all reports shall be obtainable on demand or output automatically as specified by the user. All report data shall be maintained on disk for future reference.

**643.02.4.5--Operator Interface.** The central-office computer software shall utilize the keyboard and the color graphic monitor of the personal computer as the primary interface between the operator and the system.

**643.02.4.5.1--Data Entry/Display.** All terminology shall be in English language/traffic engineering terms. No elaborate codes, special alphanumeric or complex procedures shall be required. A menu approach shall be utilized with appropriate prompts to allow an operator, unskilled in computers, the ability to operate the system.

Intersection and System parameters shall be organized and displayed in a tabular format with simple provisions for forward and back paging capability. Color shall be used exclusively to emphasize user changeable parameters and geometric displays as well as for highlighting instructional and descriptive areas of the display.

**643.02.4.5.2--File Management.** The central-office computer software shall provide for disk resident files of configuration data for all on-street masters and all local system intersections. These disk files shall be utilized to review configuration data without on-line activities, serve as a base line for modification prior to downloading new configuration parameters, or as a reference for comparison with uploaded configuration data.

**643.02.4.6--Isolated Intersection Management Option.** The central-office computer software shall include the capability of accessing system controllers at remote intersection locations. This capability shall include total access to all controller timing parameters, all intersection alarm conditions, all intersection performance measurements and statistical information, and access to all intersection status conditions in real time without the use of an on-street master.

This intersection management feature shall utilize the local system intersection controller with standard dial-up telephone circuits. The software package shall enable the Engineer to communicate with the isolated intersection in order to monitor current operation; record and analyze traffic conditions by time and pattern; modify, upload and download any controller program; and reduce maintenance cost.

The software package shall be user interactive and shall provide the Engineer total access to the complete files of timing and historical data for up to as many as 512 individual intersections. This access shall allow the Engineer the capability to review field maintenance needs over months or years and review traffic trends by day or hour within the day over a week or month period of

analysis.

**643.02.5--Training Requirements.** User training shall be provided by qualified instructors in Systems Operations and Systems Maintenance.

Personnel shall be trained to operate the system, analyze systems performance and revise critical operating parameters based on the analysis. This segment of the training program shall be a minimum of 16 hours duration.

Maintenance personnel shall be given training on maintenance and repair of all customer serviceable equipment. This segment shall include field level troubleshooting as well as bench repair. The duration of this segment of the training program shall be a minimum of eight hours.

**643.02.6--Documentation.** Complete system documentation shall be provided. Such documentation shall as a minimum consist of:

- Three complete systems operating manuals;
- Three sets of wiring diagrams and system block diagrams; and
- One copy of system operating software, resident on CDROM

**643.02.7--Quality Provisions and Warranty.** The On-Street Master, and the Communications equipment shall successfully meet the NEMA requirements as applicable.

The master unit shall be warranted to be free from defects in workmanship and material for two years from the date of shipment by the manufacturer. Any components found to be defective shall be replaced free of charge.

**643.02.8--Software Updates.** The supplier and/or manufacturer shall notify the user, in writing, whenever there is any modification or update to the closed loop on-street master system. Notification shall include an explanation of the changes made. If modifications to the software are released during the warranty period, the manufacturer shall provide the user the updates at no additional cost.

**643.03--Construction Requirements.**

**643.03.1--System Turn-On.** Prior to the system being turned on, the supplier is required to have input the appropriate phase, coordination, time base, preemption, system, alarms and communication data into the software's database. The data will be provided to the supplier by the Engineer. The supplier is also required to include in the database, a diagram of the overall, interconnected system.

At the time of the system turn on, qualified personnel familiar with the system operation and maintenance functions shall be present at the location of the central

office computer system to help in troubleshooting any problems should they occur.

**643.04--Method of Measurement.** Closed loop on-street master system will be measured as a unit quantity per each, such measurement being inclusive of the on-street master unit, housing, auto dial/auto answer modem, connectors, wiring, and central-office computer software and hardware, and including all materials, work, training, testing, and incidentals necessary for a complete and operable unit in place and accepted.

**643.05--Basis of Payment.** Closed loop on-street master system, measured as prescribed above, will be paid for at the contract unit price per each, which price shall include the installing, connecting, and testing, and for all equipment, labor, tools, and incidentals necessary to complete the work.

Payment will be made under:

643-A: Closed Loop On-Street Master System - per each

## **SECTION 644 - OPTICAL EMERGENCY VEHICLE PRIORITY CONTROL SYSTEM**

**644.01--Description.** The system shall use optical communication to identify the presence of designated priority vehicles and cause the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. The system requires no attention of the vehicle operator other than a simple "emitter on" switch located in the vehicle which is to remain "on" until the emergency vehicle reaches its destination. The system shall operate on a first-come, first-served basis.

**644.02--Materials.**

**644.02.1--General.**

**644.02.1.1--Matched System Components.** The system shall be comprised of four (4) basic matched components:

- (a) Optical Emitter Assembly
- (b) Optical Detector
- (c) Optical Detector Cable
- (d) Traffic Signal Phase Selection System

**644.02.1.2--System Requirements.** Priority traffic signal phase selection shall be activated by an optically transmitted signal of fourteen thousand and thirty-five cycles per second (14.035 MHz) or upon the actuation of a test switch.

**644.02.1.3--Adjustable Timing Capability.** The system shall provide adjustable timing capability to insure adequate minimum traffic signal displays and timing when priority control is active.

**644.02.1.4--Multiple Optical Detectors Input.** The system shall provide for up to three (3) detectors for each channel to accomplish the following:

- (a) Sufficient time to deliver the desired traffic signal display in accordance with the minimum times required to terminate non-desired traffic signal displays.
- (b) Continuous contact between the optical emitter equipped vehicle and the phase selector unit due to line of sight obstructions.

**644.02.1.5.--Safety Requirements.** Abnormal display sequences such as "Red to Yellow to Red" will not occur. Transitions from green to red without a minimum three (3) second yellow change interval will not occur. The system shall cause the traffic signal controller to deliver the desired traffic signal display even if the optical energy signals are interrupted before the desired display is obtained. The system shall allow the traffic signal controller to resume normal timing operation after the desired signal display is obtained and optical signals cease.

**644.02.2--Optical Detector.**

**644.02.2.1--General.** The optical detector shall be a light-weight, weather proof device capable of sensing and transforming pulsed optical energy into electrical signals for use by the traffic signal phase selection equipment.

**644.02.2.2--Functional Requirements.** The optical detector unit shall perform the following functions and meet the requirements listed below:

- (a) The unit shall be high-impact polycarbonate construction with stainless steel and/or brass hardware. The unit shall be designed for easy mounting at or near an intersection on mast arm, pedestal, pole or intersection span wire.
- (b) The unit shall accept optical signals from two (2) directions and provide a single electrical output signal. The unit shall include a design feature to allow aiming of the two optical sensing inputs for hills, skewed approaches or slight curves.
- (c) The unit shall have built-in terminal strip to simplify wiring connections. The unit shall receive power from the traffic signal phase selector equipment and have internal voltage regulation to be operational from 16 to 40 volts AC.
- (d) The unit shall be responsive to the optical emitter at a distance of 1,800 feet. The unit shall deliver the necessary electrical signal to the traffic signal phase selector equipment via up to 1,000 feet of optical detector

cable.

- (e) The unit shall employ replacement circuit board assembly and photocells to facilitate repair.

**644.02.3--Optical Detector Cable.** The optical detector cable shall meet the requirements listed below:

- (a) The cable shall guarantee delivery of the necessary quality signal from the optical detector to the traffic signal phase selector equipment over non-spliced distance of 1,000 feet. The cable shall guarantee sufficient power to the optical detector over a non-spliced distance of 1,000 feet.
- (b) The cable shall be of durable construction for installation by direct burial, in conduit or mast arm, or exposed overhead supported by messenger wire. The weight of the cable shall have a minimum insulation rating of 600 volts and a temperature rating of 80°C.
- (c) The cable shall have three (3) conductors of AWG 20 stranded, individually tinned copper color coded as follows:
  - 1. Orange for delivery of optical detector power (+)
  - 2. Blue for optical detector power return (-)
  - 3. Yellow for optical detector signal

The conductors will be shielded with aluminized polyester and have an AWG #20 stranded and individually tinned drain wire to provide signal integrity and transient protection. The shield wrapping shall have 20% overlap to ensure integrity following conduit and mast arm pulls.

**644.02.4--Traffic Signal Phase Selection Equipment.**

**644.02.4.1--General.** The priority control system shall be capable of interfacing with electro-mechanical controllers and solid state controllers with or without internal priority control capability.

**644.02.4.2--Phase Selector For Electro-Mechanical Controllers.** The phase selector for electro-mechanical controllers shall:

- (a) Have solid-state logic with relay contact outputs.
- (b) Sense a minimum of five (5) yellow signal displays.
- (c) Sense the desired green phase for each channel.
- (d) Have front panel interval timing selections as follows:
  - 1. Green - one (1) to ten (10) seconds in one (1) second increments each channel.
  - 2. Yellow - one (1) to ten (10) seconds in one (1) second increments each channel.
  - 3. Shall have X2 switch to double timing and for both channels.
- (e) Have one (1) optical detector input per channel with expansion



capability up to four (4) per channel via an auxiliary detector coupling unit.

- (f) Have recessed range controls to adjust optical sensitivity.
- (g) Have solid-state light emitting diode (LED) indicators for "Power-On", "Signal" being received, Channel "A" or "B" call registered, and "Advance" circuit operation.
- (h) Have a test switch which operates to deliver an "A" or "B" channel call.
- (i) Have a switch to enable "Recall" to channel "A" after channel "B" call dropout for efficient resynchronization.
- (j) Have a control for adjusting the pulse width of the advance or manual pulses.
- (k) Have "commit to green" logic to insure delivery of desired green.
- (l) Be disabled during flash or preempt operation such as railroad, draw-bridge, etc.
- (m) Be capable of disabling local coordinators during priority calls.
- (n) Be capable of informing master controllers or computers that priority calls are being serviced.
- (o) Recognize signals from either a high or low priority optical energy emitter assembly.
- (p) Operate over a voltage range of 95 to 135 volts AC, 60 Hz.

**644.02.4.3--Phase Selector For Solid-State Controllers.** The phase selector for solid-state controllers shall:

- (a) Be a solid-state modular, microprocessor controlled, two (2) channel, four (4) phase, high priority electronic device expandable to four channel, eight (8) phase, dual-ring control.
- (b) Contain the optical recognition, traffic signal sensing and output circuitry to direct the controller towards the desired intersection signal displays utilizing existing controller inputs.
- (c) Have crystal controlled optical recognition and timing circuits.
- (d) Continuously monitor all Green, Walk and Pedestrian Clearance displays for smooth transition from controller to phase selector interval timing.
- (e) Have the following user settable timing available for all monitored displays.
  1. Green(s) - Zero (0) to nine (9) seconds in one (1) second increments.
  2. Walk(s) - Zero (0) to nine (9) seconds in one (1) second increments.
  3. Ped. Clear - Zero (0) to nine (9) seconds in one (1) second increments.
  4. "X2 Green" timing switch to double green timing and increments.
  5. "X2 Ped." timing switch to double ranges and increments.
- (f) Have the following user settable switches:
  1. "Ring Assignment" to match unit to controller configuration.
  2. "Desired Green(s)" for each channel to select from available

controller phases.

3. "Recall green(s)" to select from available controller phases upon priority call dropout.
- (g) Have capability for up to three (3) optical detector inputs per channel.
- (h) Have recessed range controls of three per channel to adjust optical detector sensitivity.
- (i) Have solid-state LED indicators for "Power-On", "Fault", "Advance", "Recall" active, and "Call" for each available channel which will flash during optical call validation and be steady-on during valid call registration and test switch operation.
- (j) Have "Test" switches to verify all Call and Recall functions.
- (k) Have capability to be disabled during flash or preempt.
- (l) Have opto-isolation on all controller interfacing outputs.
- (m) Monitor the 115-volt AC signals as delivered to the traffic displays.
- (n) Have opto-isolation on all signal display monitor inputs.
- (o) Be capable of disabling local coordinators during priority calls.
- (p) Be capable of informing master controllers or computers that priority calls are being serviced.
- (q) Have opto-isolation auxiliary outputs with relay drive capability which will be active during the following conditions:
  1. "Unit Active" - a Call or Recall activity is in progress.
  2. "Channel Active" - one (1) per available channel.
  3. "Call Satisfied" - the desired green(s) for the active channel is/are present.
  4. "Walk Active" - the unit is active and a Walk is being displayed.
  5. "Ped. Clear Active" - the unit is active and a Flashing Don't Walk is being displayed.
- (r) Be intended for interfacing with controllers with nominal 24-volt I/O logic levels and have the following capabilities:
  1. "Vehicle Calls" - always logic common.
  2. "Vehicle Skips" - always logic common.
  3. "Ped Skips" - always logic common.
  4. "Delayed Force-off" - logic common of +24 volts.
  5. "Stop Time" - logic common or +24 volts.
  6. "Advance" - logic common or +24 volts.
- (s) Have automatic thermo-resettable optical detector power protection.
- (t) Contain controller manipulation parameters within the unit to allow customization via switch selections and minor wiring variations.
- (u) Properly identify a high priority demand with one high priority emitter and any combination of up to nine low and high priority emitter signals being received simultaneously and asynchronously on any channel.

#### **644.02.5--Reliability.**

**644.02.5.1--General.** All equipment supplied as part of the emergency vehicle priority control system intended for use in the controller cabinet shall meet the

electrical and environmental specifications spelled out in the NEMA standards publication TSI-1983 Part 2.

**644.02.5.2--Environmental Conditions.** All equipment supplied as part of the emergency vehicle priority control system intended for use in or on emergency vehicles shall operate properly under any combination of the following environmental conditions:

- (a) Temperature Range: -30°F to +165°F
- (b) Relative Humidity: 0 to 95%

**644.02.6--Documentation.** After an award, the manufacturer or authorized representative shall be responsible for system documentation including the following:

- (a) Acquiring all relevant controller information.
- (b) Determine the number of vehicles phase, greens.
- (c) Determine the desired greens for priority approaches.
- (d) Determine ring configuration of controller.
- (e) Establish pedestrian requirements.
- (f) Establish minimum green times for non-priority phases.
- (g) Establish the manipulation method of each controller type.
- (h) Supply interface information to installer.
- (i) Assist in system checkout prior to acceptance by:
  - verifying proper installation per recommended interfaces.
  - verifying that optical ranges are properly set.
  - verifying that phase selector timings or controller software timings\* are properly set.

\* System checkout requirements when using the plug-in version of phase selector shall include verification that when two plug-in units are used, the controller shall recognize high priority over low priority and first-come, first-served. All possible conditions of priority control shall be considered. This may require software and/or hardware changes in the traffic controller. Software programming of these controllers is the responsibility of the purchasing/using agency.

- (j) Instruct emergency vehicle operators or their representatives in the operation of the system.
- (k) Instruct maintenance personnel in routine maintenance of the system.

#### **644.02.7--Warranty.**

**644.02.7.1--General.** Manufacturer shall warrant that, provided the priority control system has been properly installed, operated and maintained, component parts of a matched component system that prove to be defective in workmanship

and/or material during the first ten (10) years from date of shipment from manufacturer shall be covered in a documented system protection plan. The protection plan shall warrant that component parts of a matched component system that prove to be defective in workmanship and/or material during the first (5) years from date of shipment from manufacturer will be repaired at no charge and that extended coverage with a fixed repair deductible applies for an additional five (5) years. In total, the warranty coverage shall assure ten (10) year operational reliability and interface compatibility with future components designed for the system. A copy of the warranty outlining the conditions stated above shall be supplied with bid.

**644.02.7.2--Certification.** The manufacturer of the priority control system shall certify that all component products are designed, manufactured and tested as a system of matched components and will meet or exceed the requirements of this specification.

**644.02.7.3--Annual Inspections.** The manufacturer shall be required to send a representative to inspect each installation annually to test the system to insure it is in working order, and to document the test in a letter to the MDOT Traffic Engineering Division.

**644.03--Construction Requirements.** The emergency vehicle priority control system will be installed as part of the traffic signal system which it controls by the Prime Contractor and/or electrical sub-contractor. All installation requirements of the equipment manufacturer shall be followed unless otherwise directed by the Engineer. The completed installation shall present a neat and positive appearance and will not in any way interfere with the proper operation of the traffic signal system installation of which it is a part. The system manufacturer will provide all of the necessary system documentation as required to the installer and to the traffic signal equipment manufacturer so that installation of this system can be coordinated. All normal requirements for the installation of traffic signal controllers, and related equipment as outlined elsewhere in the specifications will be observed during the installation of this system.

**644.04--Method of Measurement.** Optical detector and phase selector of this system will be measured per each and will include all items and work necessary to complete the installation as shown on the plans. Optical detector cable will be measured by the linear foot. Measurement shall be computed horizontally along the conduit, messenger cable or mast arm which the cable is placed, from center to center of the several installations comprising the circuits. No extra length will be allowed for vertical measure of any kind; or for sag in aerial supported cable. The terminals for the measurements of lengths will be considered specifically as the center of the pull boxes, poles, optical detectors or controllers.

**644.05--Basis of Payment.** Optical detector, optical detector cable and phase

selector, measured as prescribed above, will be paid for at the respective contract unit price for each of the system components. Such prices shall be full compensation for furnishing, installing, connection and testing all materials; for pulling through conduit, mast arms and poles for attaching to messenger cable; for final cleanup; and for all labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

- 644-A: Optical Detector - per each
- 644-B: Optical Detector Cable - per linear foot
- 644-C: Phase Selector, \_\_\_\_ Channel(s) - per each

**SECTION 645 - FLASHER ASSEMBLY**

**645.01--Description.** This work consists of furnishing flasher assemblies complete in cabinet and installed in accordance with these specifications and the details shown on the plans.

**645.02--Materials.**

**645.02.1--Material Requirements.** Materials for flasher assemblies shall meet the requirements of the following Subsections:

Cabinets .....	722.13
Circuit Breakers .....	722.07

**645.02.2--Performance Requirements.**

**645.02.2.1--General.** Each flasher and its associated equipment shall be designed to operate on 115 volts, 60 Hz, single phase, alternating current. Variations in the voltage of the power supply of  $\pm 10\%$ , or sustained temperatures inside the cabinet between -20°F and 165°F shall not change the total flash rate. Heater elements shall not be used to attain compliance with these requirements. Traffic vibration shall not affect normal operations.

**645.02.2.2--Specific Requirements.**

**645.02.2.2.1--Flasher Unit.** Each flasher unit shall be flashed at not less than 50 nor more than 60 flashes per minute, with approximately 50 percent dwell time. A two circuit flasher mechanism, alternate flash, and three flasher field circuits for each of the two flasher circuits will be required.

The flasher unit shall meet the requirements of NEMA Standard Publication TS-1-1983 Traffic Control Systems, Section 8. The flasher outputs shall be rated at 15 amps.

**645.02.2.2.2--Wiring.** All wiring shall be neatly bundled and secured with plastic cable ties. All terminals shall be labeled. All leads shall be identified by stamped aluminum or printed plastic labels to correspond with the plans. The outgoing signal circuits shall be of the same polarity as the line side of the power supply, and the common return of the signal circuits shall be of the same polarity as the ground side of the power supply. The ground side of the power supply shall be carried throughout the flasher in a continuous circuit and shall be secured to a ground bus bar in an approved manner. All conductors shall be terminated in the flasher cabinet by means of a pressure grip two pole molded insulated barrier terminal strip(s) of sufficient physical and electrical capacity. The terminal strip(s) shall be mounted horizontally on the inside of the cabinet back approximately three inches from the bottom of the cabinet. All wiring to the terminal strip(s) except the incoming field circuits shall be performed by the controller manufacturer. The terminal strip(s) shall mount at least:

- (1) Two terminals for the power supply.
- (2) An unfused terminal for neutral side of power supply line.
- (3) One terminal for each signal lamp circuit and one terminal for the common return from each signal face.

An approved lightning arrester shall be installed in each cabinet adjacent to the terminal strip used for grounding.

**645.02.3--Flasher Cabinets.** Cabinets shall be minimum 0.185-inch cast aluminum, sheet aluminum or minimum of 0.080-inch reinforced sheet steel, and shall be of clear-cut design and appearance. The cabinet shall provide ample space for housing all equipment and components. Unless otherwise specified, controller cabinets shall be at least 12 inches wide by 13 inches high by 10 inches deep.

Doors. A hinged door or doors shall provide complete access to the interior of the cabinet. The door(s) shall fit against a rain-tight gasket. The door(s) shall be provided with a cabinet lock and shall have stamped or raised outside designation, "Traffic Control", or other approved identification. Two keys shall be furnished for each type lock used. The door hinges and pins shall be of corrosion resistant metal. Pins shall be solid rod, at least 1/8 inch diameter, except if continuous hinges are furnished, the pins shall be continuous the full length of the hinges and shall be not less than 1/16 inch diameter.

### **645.03--Construction Requirements.**

**645.03.1--Construction Details.** The flashers in cabinet shall be installed at the

locations and as indicated on the plans and in conformance with the requirements herein stated.

**645.03.2--Tests and Warranties.** After completion of flasher units, the Contractor shall demonstrate by tests to the Engineer's satisfaction that:

- (1) all circuits are continuous and free from short circuits,
- (2) that all circuits are free from unspecified grounds,
- (3) that the resistance to ground of non-grounded conductors is at least one megohm at 60°F measured with a 1000 ohms per volt megger, and
- (4) that the ground resistances are not more than 25 ohms.

**645.04--Method of Measurement.** Flasher assembly will be measured as a unit quantity per each, which measurement shall include all items necessary to complete the installation.

**645.05--Basis of Payment.** Flasher assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for all construction, erecting, installing, connecting; for cabinets, flashers, circuit breakers, ground wire, straps, entrance fittings, for final cleaning up and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

645-A: Flasher Assembly - per each

## **SECTION 646 - REMOVAL OF EXISTING TRAFFIC SIGNAL EQUIPMENT**

**646.01--Description.** This work consists of removing all existing traffic control equipment that will no longer be required.

**646.02--Blank.**

**646.03--Construction Requirements.** Existing traffic signals, traffic controllers, span wires, control wires, interconnect cable, etc. will be removed by the Contractor. Existing traffic signal support poles that are no longer required and have no other utilities attached will be removed. The Contractor shall restore areas disturbed by the removal of the existing equipment to the satisfaction of the Engineer.

When salvaged by the State, all removed equipment will be identified by a tag noting its location and date of removal. The Engineer shall be informed of the items removed, their location and date of removal. Removed items will be stored

on the project and the Contractor shall notify and coordinate with the State for the return of salvaged traffic signal equipment. Unless otherwise noted in the contract, all loading and hauling of State-salvaged traffic signal equipment will be the responsibility of the State.

**646.04--Method of Measurement.** Removal of existing traffic signal equipment will be measured as a unit lump sum quantity. Such measurement shall include removal, any required tagging and storing of signal equipment, span wire, interconnect cable, etc.

**646.05--Basis of Payment.** Removal of existing traffic signal equipment, measured as prescribed above, will be paid for at the contract lump sum price, which price shall be full compensation for removal and disassembly of existing traffic signal equipment, for restoration of areas disturbed by removal and for furnishing all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

646-A: Removal of Existing Traffic Signal Equipment

- lump sum

## SECTION 647 - PULL BOXES

**647.01--Description.** This work consists of furnishing all materials required to install pull boxes at locations indicated on the plans in conformity with the plans and these specifications.

**647.02--Materials.** Pull boxes shall meet the requirements of Subsection 722.06.

**647.03--Construction Requirements.** The cover elevation of pull boxes shall be flush with sidewalks and approximately one inch above earth or sodded areas. Positions of pull boxes are shown on the plans in their relative positions only and may be repositioned with the approval of the Engineer or inspector to suit local conditions. If a pull box is shown to be installed in soil, a concrete collar shall be poured, as shown by detail on the plans, to ensure firm placement.

**647.04--Method of Measurement.** Pull box of the type specified will be measured as a unit quantity per each.

**647.05--Basis of Payment.** Pull box, measured as prescribed above, will be paid at the contract unit price per each, which price shall be full compensation for furnishing materials; for installing and final cleanup; and for all equipment, labor, tools and incidentals necessary to complete the work.

Payment will be made under:



647-A: Pull Box, Type

- per each

## SECTION 648 - RADIO INTERCONNECT

**648.01--Description.** This work consists of adding radio interconnect capabilities to local and master controller locations in lieu of hard wire interconnect.

**648.02--Materials.** Each local intersection shall have a local transceiver, power supply and an antenna. A special transceiver antenna shall be provided at the master location.

**648.02.1--RF Data Link for Local Controller Communication.** Communications between the master and the local intersections shall be performed via RF Data Link. The radio signal communication shall be done in the 900-MHz data frequency bands.

**648.02.2--Repeaters.**

**648.02.2.1--Specific Requirements.**

**648.02.2.1.1--Antennas.** Two antennas are required at repeater stations, one for each radio. Measures must be taken to minimize the chance of interference between these antennas. One effective technique for limiting interference is to employ vertical separation. In this arrangement, one antenna is mounted directly over the other, separated by at least four feet. This takes advantage of the minimal radiation exhibited by most antennas directly above and below their driven elements.

Another interference reduction technique is to cross-polarize the repeater antennas. If one antenna is mounted in the vertical plane, and the other in the horizontal plane, an additional 20 dB of attenuation can be achieved. Remember that the corresponding stations must use the same antenna orientation when cross-polarization is used.

**648.02.2.1.2--Interface Wiring.** A null modem cable is required between the Data Interface connectors of the two radios forming a repeater station. This allows them to freely exchange data even though they are both configured as DCE devices.

**648.03--Construction Requirements.** The Contractor will be responsible for verifying the integrity of the communication links between the local intersections and the master.

**648.04--Method of Measurement.** Radio interconnect and repeater installation

will be measured as a unit quantity per each. Measurement shall include controller/master modifications, transceiver, power supply, antenna and all other items necessary to complete the installation to provide appropriate RF Data Link.

**648.05--Basis of Payment.** Radio interconnect and repeater installation, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract; which price shall be full compensation for furnishing all materials; for installing, connecting and testing; and for all equipment, labor, tools, and incidentals necessary to complete the work.

Payment will be made under:

- 648-A: Radio Interconnect, Installed in New Controller Cabinet - per each
- 648-B: Radio Interconnect, Installed in Existing Controller Cabinet - per each
- 648-C: Radio Repeater Installation - per each

**SECTION 649 - VIDEO VEHICLE DETECTION**

**649.01--Description.** This work consists of furnishing all component materials required to enable video detection capabilities to traffic signal locations in lieu of other methods of vehicle detection and assembling, constructing, erecting, and installing same in conformity with these specifications, to insure properly operating unit(s) in accordance with the design(s) and at the locations shown on the plans or as directed. The video vehicle detection system shall detect vehicles on a roadway using only video images of vehicle traffic and provide detector outputs to a traffic controller or similar device.

**649.02--Materials.** Each location shall have one to four video image sensors as required, isolation amplifiers for video cabling, a control unit, and a pointing device. The system shall include personal computer software which allows detection of vehicles in multiple lanes using only video images.

**649.02.01--Functional Capabilities.** The control unit shall process video from up to four video sources simultaneously. The sources may be video image sensors or video tape players. The video signal shall be input to the control unit in RS 170 format. The video signal shall be digitized and analyzed in real time.

The control unit shall detect the presence of vehicles in up to 24 detection zones per image sensor. Each detection zone shall be approximately the width and length of one car. Detector zones shall be programmed via a menu displayed on a video monitor and a pointing device connected to the control unit. The menu shall facilitate placement of the detector zones. A separate computer shall not be required for programming detection zones.

The control unit shall store up to five different detector zone patterns for each image sensor field of view. The control unit shall be able to switch to any one of the up to five different detector zone patterns within one second of user request via menu selection with the pointing device. The control unit shall detect vehicles in real time as they travel across each detection zone.

The control unit shall have an RS232 port for communications with an external computer. The control unit shall accept new detector patterns from an external computer through the RS232 port, when the computer uses the correct communications protocol for unloading detector patterns.

**649.02.02--Vehicle Detection.** A total of up to 144 individual detection zones shall be supported. A single detection zone shall be capable of replacing multiple loops, and detection zones may be associated together by a Boolean logical or function to indicate vehicle presence on a single phase of traffic movement. Placement of detection zones shall be done by using only a pointing device and a graphical interface built into the control unit to draw the detection zones on the video image from each video image sensor. Detection zones shall be allowed to overlap one another. Up to five detection zone patterns shall be saved for each image sensor within the control unit memory, and this memory shall be protected from loss during power outages. Selection of the detector zone pattern for current use shall be done through a menu. When a vehicle is detected crossing a detector zone, the detector zone shall flash a symbol on the video image to confirm the detection of the vehicle.

Detection shall be no less than 99% accurate in good weather conditions, and no less than 96% accurate under adverse weather conditions such as rain, snow, or fog. Detection accuracy is dependent upon image sensor quality and placement, and these accuracy levels do not include allowances for occlusion or poor video due to image sensor location or quality. Detector placement from the image sensor shall not be more than the distance of ten times the mounting height of the image sensor. The control unit shall provide vehicle presence detection through either a NEMA TS1 or NEMA TS2 port.

**649.02.03--System Hardware.** The control unit shall be housed in a durable metal enclosure suitable for shelf mounting in a roadside controller cabinet. When mounted outdoors in the enclosure, the image sensor shall operate satisfactorily within the environmental conditions specified in NEMA Standards TS-1 Section 2. Surge ratings shall be as set forth in the NEMA TS2 specification.

The control unit shall include a RS232 port for serial communications with a remote computer. This port shall be a 'D' subminiature connector on the front of the control unit. The control unit shall include a port for transmitting detections to a traffic controller. This port shall be a 'D' subminiature connector on the front of the control unit.

The front of the control unit shall include four BNC video inputs for RS 170 video. Each video input shall include a switch selectable 75-ohm or high impedance termination to allow video to be routed to other devices, as well as input to the control unit for vehicle detection.

The front of the control unit shall include one BNC video output. Any one of the four video inputs shall be selectable for output on this BNC connection via the pointing device at the control unit, or through software and a personal computer connected to the RS232 port via a full duplex modem link. The video inputs to the control unit shall include transient voltage suppression and isolation amplification that shall assure the 1-volt peak-to-peak video signal integrity is maintained despite video cabling losses and externally induced transients.

The control unit enclosure shall be bonded to good earth ground.

**649.02.04--System Image Sensor.** The video cameras used for traffic detection shall be furnished by a control unit supplier and shall be qualified by the supplier to ensure proper video detection system operation. The image sensor shall produce a usable video image of vehicles under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the image sensor shall produce a usable video image shall be the minimum range from night time to day time for the site, but not less than the range from 0.1 lux to 10,000 lux. The image sensor shall use a CCD sensing element, and shall output monochrome video with resolution of not less than 350 lines vertical and not less than 500 lines horizontal.

The camera shall include auto-iris control based upon average scene luminance and shall be equipped with an auto-iris lens with focal length and maximum aperture selected to suit the deployment site. The lens auto-iris shall be adjusted to minimize image variations. The image sensor shall include automatic gain control to produce a satisfactory image at night.

The image sensor shall be housed in an environmentally sealed enclosure pressurized with dry gas to minimize the formation of condensate and extend the life of the image sensor and lens. The image sensor enclosure shall be equipped with a sunshield that prevents sunlight from directly entering the lens. The sunshield shall include a lip to prevent water and ice from entering the image sensor field of view. The image sensor enclosure shall include a thermostatically controlled heater to assure proper operation of the lens iris at low temperatures and prevent moisture condensation on the optical face plate of the enclosure. When mounted outdoors in the enclosure, the image sensor shall operate satisfactorily within the environmental conditions specified in NEMA Standards TS-1 Section 2.

The image sensor shall be powered by 120-VAC 60-Hz, or 220-VAC 50-Hz power. The image sensor enclosure shall be equipped with separate weather tight

connectors at the rear of the enclosure for power and video to allow diagnostic viewing of video at the image sensor while the image sensor is mounted and powered-up on a mast arm or pole. The video signal output by the image sensor shall be in RS 170 format. The video signal shall be fully isolated from the image sensor enclosure and power cabling.

### **649.03--Construction Requirements.**

**649.03.01--Installation.** The supplier of the video detection system shall furnish complete documentation describing installation requirements within 10 days of placement of order. Such documentation shall include descriptions of all required cabling, mounting hardware, image sensors, cabinet space, and power. Suitable video cabling and connections shall be installed to ensure the video signal losses between each image sensor and the control unit do not exceed 3 db. All power cabling shall be installed to comply with the National Electrical Code, as well as local electrical codes.

The Contractor shall provide factory certified technicians to set detector zones initially and to adjust the zones as required should the project have multiple phases in the traffic control plan.

**649.03.02--Contractor Training.** Installation of the video detection system shall be as recommended by the supplier and performed by a Contractor trained and certified by the supplier. Where time does not reasonably permit training of the installing Contractor, a supplier factory representative shall supervise and assist a Contractor during installation of the video detection system.

**649.03.03--User Training.** The supplier of the video detection system shall provide an eight-hour operations and maintenance training class with suitable documentation for up to five persons selected by the Department. The operations and maintenance class shall be scheduled at a mutually acceptable time and location.

**649.03.04--Warranty.** The video detection system shall be warranted to be free of defects in materials and workmanship for a period of two years from date of shipment. During the warranty period, the supplier shall repair or replace with new or refurbished material, at no additional cost to the State, any product containing a warranty defect, provided the product is returned postage-paid by the Department to the supplier's factory or authorized warranty site. Products repaired or replaced under warranty by the supplier shall be returned with transportation prepaid by the supplier.

During the warranty period, technical support shall be available from the supplier via telephone within four hours of the time a call is made by the Department, and this support shall be available from factory certified personnel. During the warranty period, updates and corrections to control unit software shall be made

available to the Department by the supplier at no additional cost.

**649.03.05--Maintenance and Technical Support.** The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the video detection system. Spare parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale of said spare parts.

The suppliers shall maintain an ongoing program of technical support for the video detection system. This technical support shall be available via telephone or via personnel sent to the installation site upon placement of an acceptable order at the supplier's then current pricing and terms of sale of said technical support services.

**649.04--Method of Measurement.** Video vehicle detection will be measured as a unit quantity per each for each type of video vehicle detection system installation. Measurement shall include controller modifications, hardware, connectors, wiring, software, incidentals, and all other items necessary for a complete and operable unit in place and accepted.

**649.05--Basis of Payment.** Video vehicle detection, measured as prescribed above, will be paid for at the contract unit price per each video vehicle detection system installed, which price shall be full compensation for furnishing all materials, for installing, connecting and testing, and for all equipment, labor, tools, and incidentals necessary to complete the work.

Payment will be made under:

649-A: Video Vehicle Detection, New Installation, \_\_\_\_ Cameras - per each

649-B: Video Vehicle Detection, Existing Installation, \_\_\_\_ Cameras - per each

## SECTION 650 - ON-STREET VIDEO EQUIPMENT

**650.01--Description.** This work shall consist of furnishing and installing equipment necessary for a complete working system of on-street traffic monitoring video. The system shall support complete access from the local traffic agency as well as access from the MDOT state-wide traffic management system. The traffic video system shall provide all components and integration required for full operation including, but not limited to, on-street camera equipment, communication links & equipment, and central office materials & equipment.

High resolution, color outdoor, dome-type camera units shall be compatible with MDOT's existing switched video control system located at the MDOT Traffic Management Center (TMC). All components, cabling, integration and

installation necessary to make the camera site and local agency video management site fully functional with the State's existing video system shall be furnished by the Contractor. It is the purpose of this specification to set forth the minimum requirements for traffic monitor video systems to be used in the State's Advanced Traffic Management Systems (ATMS).

**650.02--Materials.** The outdoor camera unit shall be an outdoor, dome-type high resolution, NTSC camera assembly. The camera assembly shall be rugged and incorporate the latest CCD technology. The dome camera assembly shall include an intelligent, compatible architecture design to ensure that the system will adapt to future technologies.

The dome camera assembly shall include a smooth pan rate that delivers zoom without image jitter or jump. The unit shall include auto-focus. The unit shall include 360 degrees of rotation, continuous in both directions with variable speed and fast speed capability.

The dome camera assembly shall include 16X optical zoom and 8X electronic magnifier features thereby delivering the power of 128X zoom.

The dome assembly shall include a universal design allowing it to be used in varied configurations and with several mounts including, but not limited to, side-of-pole, corner, and flat mounting situations.

The dome camera assembly shall include a clear shatterproof globe with hard-coat for cloth cleaning without scratches. The dome camera assembly shall be equipped with sun shield, heater and ozone impervious seals.

The dome camera assembly shall provide a total integrated camera solution that can integrate with the State's ITS architecture.

Integrated multiple video switch support shall be included. This support shall provide the benefit of intelligent, compatible architecture, which allows the system to adapt to future video switching technologies.

The dome camera shall provide performance that exceeds the preset pan speed of 500 degrees per second. The dome camera shall be capable of multiple tours that provide numerous views.

During manual control, the camera assembly shall provide an adaptive, real-time system that delivers a smooth response and allows one to zoom in on objects without jitter and picture jump. The dome camera assembly shall include a universal clamp-in design and on-board protocols that interface with various popular video control systems.

The dome camera assembly shall include on-board diagnostics and nonvolatile

memory that keeps track of all maintenance. The diagnostic systems and time-date maintenance system shall help ensure that the system operates at peak efficiency.

The dome camera assembly shall include a minimum of eight (8) alarm inputs and outputs. The unit shall be addressable for up to 254 addresses. The unit shall include communication support for RS-232, RS-485, and RS-422 standards.

The dome shall include a character generator and shall support a height of 18 scan lines. Position shall be 24 characters, 12 lines per field, and available top to bottom or right to left. Color and black & white operation shall be selectable. Date line shall include multiple formats with a selectable time line of 12 or 24 hour clock. The dome assembly shall include up to 24 zone titles and the unit shall be software and hardware field upgradable.

The dome camera assembly shall include a minimum one-year manufacturer's warranty. All manufacturer's warranties and guarantees on all electrical and mechanical equipment shall be delivered to the Engineer at the final inspection. All warranties and guarantees shall be made out to the MDOT and shall begin after final acceptance of the project.

The dome camera assembly shall be capable of interfacing with the State's Video System Controller, Advanced Traffic Management System (ATMS), and Traffic Communication Network.

**650.03--Construction Requirements.** The on-street video camera(s) shall be installed at the location(s) shown on the plans. The camera(s) shall be installed in accordance with the manufacturer's recommendation, these specifications or as directed by the Engineer.

**650.04--Method of Measurement.** On-street video equipment, constructed and installed as specified in the plans will be measured per each camera installation. Such measurement shall be inclusive of camera unit, housing, pan/tilt drive, receiver/driver, mounting hardware and any enclosures necessary. It shall also include any items necessary to mount the camera unit from a mast arm pole, steel strain pole, pole extension pipe, etc.

**650.05--Basis of Payment.** On-street video equipment, measured as prescribed above, will be paid for at the contract unit price bid per each, which price shall be full compensation for furnishing all materials, for all installing, connecting, cutting, pulling and testing and for all equipment, tools, labor and incidentals necessary to complete the work.

Required cabinet facilities, including transformer and/or disconnects, will not be measured for separate payment.



Payment will be made under:

650-A: On-Street Video Equipment \*

- per each

\* Type may be specified as an option

## SECTION 653 - TRAFFIC AND STREET NAME SIGNS

**653.01--Description.** This work shall consist of furnishing and installing reflectorized regulatory and warning traffic signs and street name signs as shown on the plans and set forth herein.

This specification addresses the minimum requirements for supplying traffic and street name signs for use with span wire and mast arm mounted traffic signal systems.

**653.02--Materials.** All materials for traffic and street name signs shall be new and meet the requirements of Section 721 of the Standard Specifications.

**653.02.1--Reflective Sheeting.** Reflective sheeting for traffic and street name signs shall be Type III or Type VII retroreflective sheeting. The type and color of reflective sheeting shall be indicated on the plans or set forth herein.

**653.02.2--Sign Blanks.** Sign blanks shall be flat aluminum sign blanks constructed of 5052-H38 aluminum alloy. Blanks shall be 0.100 inches thick, degreased, deburred, etched and alodine. Sizes shall be as indicated in the plans for the specific warning, regulatory or street name sign called for and to accommodate the various legends.

**653.02.3--Sign Faces.** All sign faces shall consist of sheeting material and their legends applied to aluminum blanks specified herein using a heat vacuum method and/or by silk screening the legends only onto the backings and material. The sheeting shall be applied with legends to one side of each warning, regulatory or street name sign as shown on the plans.

The color of all faces shall consist of a reflectorized yellow, red, green or silver-white background with reflectorized black, red or white legend. The legend shall consist of letters and symbols conforming to the design of warning or regulatory signs as shown in the MUTCD and for street name signs as shown on the plans.

All letter sizes spacing shall be in accordance with FHWA and the manufacturer's recommendations to insure proper legibility with the increased reflectance.

**653.03--Construction Requirements.** All signs shall be installed in accordance with the plans and the Manual on Uniform Traffic Control Devices (MUTCD).

Signs are to be tilted in order to minimize or eliminate specular reflection.

**653.03.1--Warning and Regulatory Signs.** Warning and regulatory signs shall be installed at locations as noted on the plans with the appropriate mounting bracket and banding material.

**653.03.2--Street Name Signs.** Street name signs shall be installed at locations as noted on the plans. If installed on mast arms, they shall be attached with at least two mounting brackets and appropriate banding materials.

**653.03.3--Washers.** Washers, if recommended by the sheeting manufacturer to protect the sign surface from damage by bolts or other fasteners, shall be furnished by the manufacturer at no additional charge.

**653.04--Method of Measurement.** Traffic sign and street name sign of the type specified will be measured by the square feet, which measurement being inclusive of aluminum sign blank, applied reflective sheeting, mounting brackets and banding materials and begin inclusive of all materials, work and services necessary for a properly constructed sign.

**653.05--Basis of Payment.** Traffic sign and street name sign, measured as prescribed above, will be paid for at the contract unit price per square feet, which price shall be full compensation for furnishing the sign and mounting hardware and installing the same on the span wire, signal pole or mast arm, and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

653-A: Traffic Sign, Type - per square feet

653-B: Street Name Sign, Type - per square feet

**SECTION 657 - FIBER OPTIC CABLE (OSP)**

**657.01--Description.** All outside plant trunk cables shall be stranded loose tube design. Drop cables shall be central core or stranded loose tube design. The cable configurations shall be dictated by the particular communication path, data rate, and distance of the optical path. Three possible designs are all multimode fiber, all single mode fiber cable, or a hybrid design containing multimode and single-mode fiber. In the case of a stranded loose tube hybrid design, single-mode and multimode fibers shall not occupy the same buffer tube. Single-mode tubes shall be placed in the first available tubes in the cable, i.e., blue, orange, etc., based on cable design, multimode tubes shall follow.

**657.02--Materials.** The fiber optic cable shall meet the requirements of

Subsection 722.21, the United States Department of Agriculture Rural Utilities Services (RUS) 7 CFR1755.900 and the ANSI/ICEA Standard for Fiber Optic Outside Plant Communications Cable, ANSI/ICEA S-87-640-1992.

The cable shall be new, unused, and of current design and manufacture.

### **657-03--Construction Requirements.**

**657.03.1--Pre-Terminated Drop Cable Assemblies.** These assemblies shall be employed when connecting a camera, controller, VMS or other device the main cable when mid-span access techniques are used.

Cable used for Drop cable assemblies shall conform to Subsection 722.21.4.

Assemblies shall be factory assembled and terminated on one end with ceramic ferrule, ST compatible, heat cured epoxy connectors with an operational temperature of -40°F to +160°F. Each connector shall have a minimum of a 1-inch strain relief boot.

Insertion loss for each connector shall not exceed 0.30 dB for both single mode and multi-mode assemblies. Return loss for single mode connectors shall be >-45dB. Each assembly is to be fully tested and those test results placed on a test tag for each assembly. Each assembly is to be individually packaged within a box or reel, with the submitted manufacturer's part number marked on the outside of the package.

Individual 250 µm coated fibers shall be up-jacketed to 1/8-inch using fan-out tubing. This tubing shall contain a 900 µm Teflon inner tube, aramid yam strength members, and an outer jacket. The fan-out tubing shall be secured to the cable in an hard epoxy plug transition. Length of the individual legs shall be a minimum of three feet with the length difference between the shortest and longest legs of the assembly being no more than two inches.

### **657.03.2--System Configuration.**

**657.03.2.1--Drop and Insert Applications.** Signal from the MDOT Traffic Management Center (TMC) to local controllers, cameras, and/or variable message signs will be conveyed via the backbone and branch cables in a closed loop configuration. At each controller, the applicable fibers will be routed in and out of the applicable housing via a mid-span access splice point and a pre-terminated drop cable. Only fibers required for the drop and insert shall be cut, no other fibers in the cable shall be cut without the direction of the Engineer.

Fibers shall be routed to equipment via an Aerial Drop Cable Kit, PN DK111-B0431-XXX or Undergrade Drop Cable Kit, PN DK211-B0431-XXX or approved equal; where XXX denotes length of drop pigtail in feet. Drop Kit

shall contain appropriate closure, splice tray, splice protection, and a preterminated drop cable of specified length, and shall also include a 12-port fiber distribution cabinet and appropriate interconnect adapters and jumpers. Shall also include a 12 port fiber distribution cabinet and appropriate interconnect adapters and jumpers. Splicing shall be fusion or mechanical. Splice loss in either case shall be 0.25 dB, measured in one direction only with an OTDR at 850 nm for multi-mode and 1310 for single-mode.

The type of mechanical splice, if used, shall be approved by the Engineer prior to use. The splice shall be stored in a splice organizer/tray specifically designed for the mechanical splice used. Fusion splices shall be protected using heat shrink protective sleeves and stored in a splice organizer/tray specifically designed for the protection device.

**657.03.2.2--Point-to-Point Applications.** Signal to the local controllers will be conveyed by routing fiber optic cable directly between equipment with an appropriate fiber count cable and be directly terminated with field installable ST compatible connectors. At the end points, the cable shall be terminated via one of two methods.

For Direct Connect Applications. The fiber optic cable shall be terminated using a Spider Fan-out Kit. Any substitute termination method must have at a minimum 24 inches of 1/8-inch fan-out material jacketing for fiber protection, provide for central member strain relief, provide for antirotation and pull out. Field installable ST compatible connectors will be terminated on the fan-out and connected directly to the transmission equipment.

For Cross Connect Applications Inside Controller Cabinets. The fiber optic cable shall be terminated using a 900- $\mu$ m fanout modular design for the fiber count being terminated. The non-metallic fan-out shall attach directly to the buffer tube and transition the 250 $\mu$ m coated fibers into the fan-out tubing. The fanout shall be housed in a wall mount distribution cabinet equipped with the appropriate number of adapters. The fibers shall be connected to the transmission equipment via ST/ST fiber optic patch cables. This hardware scheme shall also be utilized for wall mount applications.

### **657.03.2.3--Fiber Optic RS-232 Communications.**

Fiber Optic Data Transceiver. The transceiver(s) shall be located at the TMC and communicate directly with the traffic controllers in the closed loop system(s). They shall be rack mountable. The fiber optic data transceiver shall be compatible with the internal modem(s) installed internally in each traffic controller. The unit shall provide transmission of RS-232 data signals over standard 62.5/125 multi-mode fiber optic cable. Transceiver shall have L.E.D. receive and transmit indicators. Transceivers shall be capable of being linked together in either repeater or star configurations. Unit shall provide for

transmission distances of up to 13,000 feet without requiring manual adjustments or line attenuators . All printed circuit boards shall be manufactured from Mil Grade specification circuit board material. Housing shall be all metal construction with all connections identified with silk screened labels. Unit shall be available in both rack mount and surface mount versions. Units shall have solid state limiters on all power lines which shall provide for automatic reset. Rack mount configurations shall have an internal D.C. power supply and a short circuit in one unit shall not affect the operation of other units powered from the common power supply. Rack mount units shall be hot swappable with no risk of damage to other units during replacement. Transceiver shall be U.L. listed and shall have the following features and characteristics:

Data Rate .....	DC-64 kbaud - NRZ
Wavelength .....	850 nm
Number of Fibers .....	2 fibers
Size, inches .....	4.2 x 3.5 x 1.0; Rack Mount: 7.7 x 5.0 x 1.0
Operating Temperature .....	-5°F to +160°F
Bit Error Rate .....	1 in E+9
Operating Mode .....	Asynchronous, simplex, or full duplex
Input/Output Level .....	±3.75 to ±12 volts
Input/Output Impedance .....	Per RS-232 specification
Optical Budget .....	14 dB; less 4 dB for 50/125 fiber
Output Power .....	25 W @ -16 dBm
Input Sensitivity .....	1 W @ -30 dBm

Connectors:

Optical .....	AT&T type ST
RS-232 .....	Female plug with screw clamps or adapter to DB-9 connector

Power:

Rack .....	115 VAC ±10%, 60 Hz PS-12 DC
Stand-alone .....	115 VAC ±10%, 60 Hz with module or +9 to 15 VDC @ 100mA

Fiber Optic Rack Mount Enclosure. The fiber optic rack shall be compatible with the RS-232 transceivers above. The unit shall provide 14 mounting slots for standard 1-inch wide rack mount version fiber optic modules. It shall have heavy duty construction and shall mount in industry standard equipment racks that accommodate 19-inch wide rack mount panels. Unit shall include a 20 VAC C.T. transformer power supply. All compatible rack mount fiber optic modules shall have an internal D.C. power supply with solid state limiters which provide automatic reset and a short circuit in one unit shall not affect operation of other units powered from the common power supply. Modules shall be hot swappable with no risk of damage to other units during replacement. Rack shall be U.L. listed and shall have the following features and characteristics:

Input Voltage .....	115 VAC - line cord
Power Supply .....	20 VAC C.T. @ 2.8A
Number of Module Slots .....	14 slots
Size, inches .....	19.0 W x 5.2 H x 7.0 D
Operating Temperature .....	-5°F to +160°F
Fusing .....	1 A slow-blow; plug-in modules individually fused

**657.03.3--Fiber Optic Patch Cables - Jumpers.** Any patch cords used for system configuration shall be compatible with fiber types and connectors specified herein. Multimode patch cords shall be orange in color. Single-mode patch cords shall be yellow in color. Jacketing material for both shall conform to the appropriate NEC requirement for the environment in which installed. All cordage shall incorporate a 900-μm buffered fiber, aramid yam strength members, and an outer jacket. Patch cords may be simplex or duplex, depending on the application. Multimode cordage attenuation shall be 3.75 dB/km @ 850 nm, 1.5 dB/km @ 1300 nm; for single-mode fibers shall be 1.0 dB/km @ 1310 nm, 0.75 dB/kin @ 1550.

**657.03.4--Fiber Optic Connectors.** All connectors used in the communication system shall be ST compatible, ceramic ferrule connectors. Factory terminated connectors shall be heat cured epoxy type with a maximum measured loss of 0.30 dB; Field installable connectors may be heat cured epoxy or no polish cleave and crimp technology, with a maximum measured loss of 0.50 dB per mated pair. The operating temperature of all connectors in the system shall be -40°F to +160°F with no more than a 0.20 dB change across the temperature range.

**657.03.5--Fiber Optic Closures.**

**657.03.5.1--OSP Closures for Aerial, Pole Mount, Pedestal, and Hand Hold Environments.** OSP closures for aerial, pole mount, pedestal, and hand hold shall be capable of accepting up to six cables in a butt splice. The closures shall be capable of storing up to eight 90-inch lengths of expressed buffer tubes.

Assembly shall be accomplished without power supplies, torches, drill kits or any special tools. Reentry shall require no additional materials. Sealing shall be accomplished by enclosing the splices in a polypropylene dome that is clamped together with a stainless steel latch and sealed with an O-ring.

Closure shall be capable of strand mounting with the addition of a strand mounting bracket.

Splice case shall be non-filled, non encapsulate to prevent water intrusion and shall allow re-entry without any special tools. The closure shall be capable of preventing a 10-foot water head from intruding into the splice compartment for a period of seven days. Testing of the closure is to be accomplished by the placing

of the closure into a pressure vessel and filling the vessel with tap water to cover the closure. Continuous pressure shall be applied to the vessel to maintain a hydrostatic head equivalent to 10 feet on the closure and cable. This process shall be continued for seven days. Remove the closure, open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure. It is the responsibility of the Contractor to insure that the water immersion test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the Engineer.

**657.03.5.2--OSP Closures for Buried Environments.** OSP closures for buried applications will incorporate the following features.

Splice case must handle up to four cables. A butt adapter, if applicable could be used to increase capacity to eight cables.

Splice case shall be non-filled, non encapsulate to prevent water intrusion, and shall allow re-entry without any special tools. The closure shall be capable of preventing a 10-foot water head from intruding into the splice compartment for a period of seven days. Testing of the closure is to be accomplished by the placing of the closure into a pressure vessel and filling the vessel with tap water to cover the closure. Apply continuous pressure to the vessel to maintain a hydrostatic head equivalent to 10 feet on the closure and cable. This process shall be continued for seven days. Remove the closure, open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure. It is the responsibility of the Contractor to insure that the water immersion test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the Engineer.

The closure shall be capable of accommodating splice organizers which accept mechanical, single fiber fusion, or multi fiber splices. The closure shall have provisions for storing fiber splices and unspliced fiber/buffer tubes. The closure shall hold a minimum of two (2) splice trays to a maximum of 15 splice trays with each tray housing up to 24 splices. The closure shall be UL rated.

Closure re-entry and subsequent reassembly shall not require specialized tools or equipment.

For compression testing, the closure shall not deform more than 10% in its largest cross-sectional dimension when subjected to a uniformly distributed load of 396 lbf at 0°F and +100°F. The test shall be performed after stabilizing at the required temperature for a minimum of two hours. It shall consist of placing an assembled closure between two flat parallel surfaces, with the longest, closure dimension parallel to the surfaces. The weight shall be placed on the upper surface for minimum of 15 minutes. The measurement shall then be taken with

the weight in place. It is the responsibility of the Contractor to insure that the compressions test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the Engineer.

**657.03.6--Fiber Optic Termination Hardware.** For cross connect applications inside controller cabinets, the fiber optic cable shall be terminated using a 900- $\mu$ m fanout modular design for the fiber count being terminated. The non-metallic fan-out shall attach directly to the buffer tube and transition the 250- $\mu$ m coated fibers into the fan-out tubing. The fanout shall be housed in a wall mount distribution cabinet equipped with the appropriate number of adapters. The fibers shall be connected to the transmission equipment via ST/ST fiber optic patch cables. This hardware scheme shall also be utilized for wall mount applications.

For rack mount applications, the fiber optic cable shall be terminated using a 900- $\mu$ m fanout modular design for the fiber count being terminated. The non-metallic fan-out shall attach directly to the buffer tube and transition the 250- $\mu$ m coated fibers into the fan-out tubing. The fan-outs shall be housed in a fiber distribution center sized for 50% growth based on the initial installation. Appropriate panels for ST adapters shall be included based on the population of the fiber cable installed. If fusion or mechanical pigtail splicing is used for termination points, a splice housing with appropriate 900- $\mu$ m pigtails and splice trays shall be used in conjunction with the fiber distribution center.

**657.03.7--Installation.** All fiber optic components will be installed in accordance with the manufacturer's instructions. All necessary interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided. All pole attachments, service loops, and conduit risers will be placed to minimize the possibility of damage as well as to facilitate future expansion or modernization.

Cable between controllers shall be lashed to a 1/4-inch EHS messenger with stainless steel lashing wire for aerial installations. The installation will be accomplished in accordance with accepted OSP construction practices. Precautions shall be taken to insure the installation specifications for the cable are not exceeded, i.e. tension, minimum bend radius. The cable shall be marked with an orange weatherproof identifying tag at each pole location, with print "Caution, Fiber Optic Cable".

The cable shall be installed in continuous runs as indicated on the plans. Splices shall be allowed only at drop points. Only those fibers necessary to complete the communication path shall be spliced, i.e. mid-span access. All other fibers in the cable(s) shall be left undisturbed; with a minimum of five feet of buffer tube coiled inside the closure.



Sufficient slack shall be left at each drop point to enable access of the cable components and splicing to occur on the ground typical two times the strand height plus 15 feet. For undergrade installations, the following minimum slack requirements shall apply: 50 feet at the pull box or controller location for mid-spans, 15 feet for point to point applications for each cable. For aerial slack storage at splice points, a radius controlling device, commonly referred to as a SNO-SHOE shall be used for securing resulting cable slack at aerial splice points and shall be mounted directly to the strand.

For aerial cable runs exceeding 6-pole spans between splice points as indicated on the plans, two opposing SNO-SHOES shall be placed on the span 50 feet apart to provide for a 100-foot service loop for future drops and for slack for repair and pole relocations.

Drop cable shall be routed to the controller cabinets via conduit risers as illustrated in the plans. The cable entrance shall be sealed to prevent water ingress.

The minimum requirement for fiber protection outside a fiber optic enclosure in ALL cases shall be 1/8-inch fanout tubing, containing a hollow 900- $\mu$ m tube, aramid strength members and an outer jacket, and shall be secured to the cable sheath.

The minimum requirement for fiber protection inside wall mount or rack mount fiber enclosure shall be 900 $\mu$ m buffering, intrinsic to the cable in the case of tight buffered fibers, or in the case of 250- $\mu$ m coated fibers, a fanout body and 900- $\mu$ m tubing secured to the buffer tube(s).

During installation, even if the tension specifications for the cable are not exceeded, the first ten feet shall be discarded.

Warning tape shall be placed 12 inches above the cable not to deviate  $\pm 18$  inches from the centerline of the optical cable. Warning tape shall be at least two inches wide and colored orange.

Permanent above-ground markers shall be placed at line-of-sight intervals. Each marker shall be visible from each adjacent marker but separated by no more than 1,000 feet.

### **657.03.8--Testing and Documentation.**

**657.03.8.1--OTDR Testing.** Prior to the installation, the Contractor shall perform on-site on the reel testing. The Contractor is required to test all fibers in each reel of cable prior to installation. This testing is for both continuity and attenuation. The tests shall be conducted at 850 nm for multimode fibers and at 1310 nm for single mode fibers. The testing shall be performed using an Optical

Time Domain Reflectometer (OTDR) via a "pigtail" splice. The resultant OTDR trace(s) shall reflect overall length and attenuation expressed in db/km. All test results shall be within +3.0% of factory supplied attenuation measurements for multi-mode fibers and single mode fibers. Testing shall be done in one direction only. Hard copy or disk based with applicable software OTDR traces for the testing shall be supplied to the Engineer by the Contractor prior to installation of cables. The Contractor may opt to accept factory results and install cable at the Contractor's risk. In either case, On-the-reel test results shall be provided to the Engineer for each cable installed.

Following installation, each section of the installed cable shall be tested for continuity and attenuation as indicated above. The traces shall demonstrate that no change in transmission characteristics has occurred during installation and that any splices meet the requirements herein. This testing can be done in conjunction with the End-to-End testing described below. The traces shall be included in the documentation package provided at the conclusion of the contract.

**657.03.8.2--Attenuation Testing.** Only connectorized spans will be tested for final End-to-End attenuation or power loss. The testing shall be performed at 850 nm and 1300 nm for multimode and at 1300 nm for single-mode fibers. The testing shall be conducted using "hand-held" optical test sets and shall be conducted using a two jumper reference. The testing shall be in one direction only. The results shall be tabulated and be include in the documentation package provided at the conclusion of the contract. Overall loss for each link shall not exceed the cumulative specified losses of the components in the link. EXAMPLE: At 850 nm, a 1-km link with two splices and a connector on each end shall not exceed 5.0 dB ((3.5dB + 0.25dB + 0.25dB + 0.5dB +0.5dB))

At the conclusion of the contract, two copies of system documentation package shall be provided. It shall include at a minimum:

- Post installation OTDR traces for each fiber.

- End-to-End Attenuation measurement for each fiber.

- A splice plan showing the location and configuration of any splices in the system as well as how the transmission scheme is set up.

- Reference manuals for equipment provided.

**657.03.9--Training and Equipment.** After the installation is complete the Contractor shall provide formal classroom training and "hands-on" operations training for proper operation and maintenance of the fiber optic plant. The training shall be conducted by a trainer with a minimum of four years of experience in training personnel on the operation and maintenance of fiber optic systems. The training shall be provided for up to six personnel designated by the Engineer and shall be a minimum of one day in duration. All training materials shall be provided by the Contractor.

**657.04--Method of Measurement.** Fiber optic cable of the type specified will be measured by the linear foot, measured horizontally along the conduit or aerially along the messenger cable. No differentiation will be made for cable installed underground or aerially.

Fiber optic drop cable and video drop cable will be measured by the linear foot from the trunk line to the controller cabinet.

All required cabinet facilities shall not be measured for separate payment. All standard or special fiber optic modems, fan out boxes, splicing devices, warning tape, above ground markers, backplane facilities, twisted pair communications cable interface devices, etc., and any other cabinet modifications required for the fiber optic system shall be included in the price bid for other items of work.

**657.05--Basis of Payment.** Fiber optic and drop cable, measured as prescribed above, will be paid for at the contract unit price bid per linear foot, which price shall be full compensation for furnishing all materials, for all installing, connecting, cutting, pulling and testing and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

- 657-A: Fiber Optic Cable, No. of fibers, No. / mode - per linear foot
- 657-B: Fiber Optic Drop Cable, No. / mode - per linear foot
- 657-C: Fiber Optic Video Drop Cable, No. / mode - per linear foot

**SECTION 661 – MULTI-CHANNEL VIDEO MULTIPLEXER**

**661.01--Description.** The multi-channel video multiplexer series shall utilize the latest state-of-the-art digital encoding and decoding for high quality video transmission and shall exceed the requirements of EIA RS-250C for medium-haul video transmission. The units shall provide transmission of up to 16-independent video channels over one multimode or single mode optical fiber and shall be able to use in unconditioned roadside or out-of-plant installations. The units shall be universally compatible with any CCTV camera system. Plug-and-play design features with LED indicators are required.

**661.02--Materials.** Multi-channel video multiplexer shall meet the requirement of Subsection 722.22.

**661.03--Construction Requirements.** The installation of each multiplexer unit shall consist of mounting in a cabinet and connecting to input and output cables as indicated on the plans or as directed and shall present a neat and workman like

appearance. The Contractor shall demonstrate to MDOT's satisfaction the operation of the multiplexer's video inputs and outputs.

**661.04--Method of Measurement.** Multi-channel video multiplexer of the type specified will be measured as a unit per each, which shall include cabinet, all wiring, hardware, other equipment and incidentals necessary to complete the work.

**661.05--Basis of Payment.** Multi-channel video multiplexer, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, construction installing; connecting, testing, and for all equipment, tools, labor and incidentals required to complete the work.

Payment will be made under:

661-A: \_\_\_\_ Channel Video Multiplexer - per each

## **SECTION 666 - ELECTRIC CABLE**

**666.01--Description.** This work consists of furnishing, erecting, installing and/or laying electric cable "mains" in conformity with these specifications and true to locations, line and grades as shown on the plans or as directed. It shall include excavating, laying, placing tracer cable or tape, backfilling, replacing sod, aerial supports and/or pull-through conduits, as applicable; and terminal boxes when not placed under other items of the contract.

**666.02--Materials.** The materials used in this construction shall be of the type and size indicated on the plans and shall conform to the applicable requirements of Subsection 722.03.

### **666.03--Construction Requirements.**

**666.03.1--General.** Except where indicated on the plans or approved by the Engineer, cables shall be spliced only in pole bases or controller cabinets. At each splice, sufficient slack shall be left in the cable for resplicing. The greatest care shall be exercised in handling all cable to avoid damage to the conductor and its coverings. No sharp bends shall be permitted to form; reels shall not be dropped; and cable with discernable damage in any part shall be rejected. Cable shall be handled and installed only by experienced personnel. All connections shall be made with approved terminal blocks meeting the requirements of Subsection 722.08.

**666.03.2--Direct Buried Cable.** Trenches shall be excavated by hand or mechanical methods to the depth and width indicated on the plans, or as directed.

The cable shall be laid on a six inch cushion as shown on the plans or as directed and covered with a similar layer. The electric cable shall be "snaked" laid in the trench. The earth backfill then shall be placed in layers of eight inches or less, and each layer compacted by approved methods to the density of adjacent ground. Cable placed under traveled roadways shall be pulled through previously placed metal conduit, and such pulling shall be incidental to work.

The ground surface backfilled trenches shall be neatly dressed, all soil shall be removed from the right-of-way, and the sod shall be replaced over the finished trench, all as directed.

**666.03.3--Support of Aerial Conductor Cable.** Aerial conductor cable normally shall be supported by messenger cable affixed by approved devices to supporting structures. In all cases the cost of messenger cable and other support devices will be included in the contract unit price bid for electric cable.

**666.03.4--Cable and Conduit.** Cable lengths required shall be obtained by accurate measurement of the runs with liberal allowances made for slack in boxes, slack for terminating and waste due to wire-grip damage. Open ends of cables shall be rubber taped at all times to avoid penetration of water or moisture into the strands of the cable. Pull-in guides, cable feeders or drawing-in protectors shall be employed to prevent damage to the cable at the duct mouth. An individual pull-in grip shall be used on each single conductor in the cable core to provide equal strain on each conductor. Cable whose jacket insulation or conductors have been damaged or displaced by pull-in grip shall be cut off and discarded before terminating. Cable shall be fed manually into the pull-in guide, cable feeder, or protector in such manner as to avoid excessive friction on the cable. Pulling shall be instantly stopped if undue tension occurs. Powdered talc, water or other lubricant, approved by the cable manufacturer, shall be used to facilitate pulling in runs over 200 feet, and may be used if desired on shorter runs. In no case shall grease be used as cable lubricant.

**666.03.5--Identifying and Tagging.** Individual phases of each signal circuit shall be identified by appropriate identifying marks, at points near each end of the cables and in each handhole or pull box.

Before connections are made at cable terminals, these marks shall be checked by talking over each conductor by means of a portable hand telephone set. Circuits shall also be identified in similar manner before terminal connections are made.

All cable entering controller cabinets, pull boxes and poles shall be identified with permanent labels or tags indicating the function of each conductor and which pole, pull box, or controller it goes to.

When required in the plans, the installation of tracer cable shall be in accordance with the requirements herein, per the manufacturer's recommendation, or as

directed by the Engineer. When tracer cable is installed in an open trench, a non-detectable warning tape will be placed directly over the buried cable, four to six inches below finished grade.

**666.03.6--Backfilling.** Granular material for backfilling buried cable trenches shall be as shown on the plans.

**666.03.7--Field Tests.** The cable shall be tested for failure in accordance with Subsection 634.03.2. The test shall be made after cable has been installed and before connections have been made.

**666.03.8--Interpreting the Test.** If a cable fails, the fault shall be located and the cable replaced between terminal points. If failure occurs in conduit, all cables in that conduit between the nearest pulling points on each side of the failure shall be withdrawn. If, in the opinion of the Engineer, the other cables in the same conduit have not been damaged, they may be reinstalled, but the cable which failed shall be replaced with new cable. After replacement of the faulty cable, and any damaged cables, all cables of that circuit shall be retested.

**666.04--Method of Measurement.** Electric cable of the type specified, constructed as specified on the plans, will be measured by the linear foot. Measurement will be computed horizontally along the conduit or messenger cable which the electric cable is placed, from center to center of the several installations comprising the circuits. No extra length will be allowed for vertical measure of any kind; for cable inside signal heads; or for sag in aerial supported cable. Tracer tape used with tracer cable will not be measured for separate payment but shall be included in the contract price for tracer cable. The terminals for the measurements of lengths will be considered specifically as the center of the pull boxes, poles, signal heads or controller cabinets.

Excavation, sod and backfill will not be measured for separate payment but shall be included in the cost of other items bid.

Messenger cable and other supporting devices for aerial electric cable will not be measured for separate payment, but shall be included in the cost of other items bid.

**666.05--Basis of Payment.** Electric Cable of the type specified, measured as prescribed above, will be paid for at the respective contract unit price per linear foot, which price shall be full compensation for furnishing, installing, connecting and testing all materials; for pulling through conduit and poles; for attaching to messenger cable; for final cleanup; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

- 666-A: Electric Cable, Direct Burial, Type, AWG \_\_, \_\_\_\_ Conductor - per linear foot
- 666-B: Electric Cable, Underground in Conduit, Type, AWG \_\_, \_\_\_\_ Conductor - per linear foot
- 666-C: Electric Cable, Aerial Supported, Type, AWG \_\_, \_\_\_\_ Conductor - per linear foot
- 666-D: Electric Cable, Aerial Supported in Conduit, Type, AWG \_\_, \_\_\_\_ Conductor - per linear foot
- 666-E: Electric Cable, Underground in Conduit, Tracer Cable - per linear foot

## **SECTION 667 - UNDERGROUND ELECTRIC CABLE - REMOVED AND RELAID**

**667.01--Description.** This work consists of excavating by hand method existing electric cable, and where present from its existing location and relaying electric cable "Mains" in reasonably close conformity with these specifications, and the locations, lines, grades as shown on the plans or directed. It shall include excavating new cable trench, relaying cable; backfilling, replacing sod, pulling through conduits as applicable; and furnishing terminal boxes, if required and not required under other items of the contract.

**667.02--Material Requirements.** Material for backfilling cable trenches shall be as shown on the plans.

### **667.03--Construction Requirements.**

**667.03.1--Excavating Existing Cable.** Existing cable, and its protective covering, if indicated on the plans, shall be removed by hand trenching, exercising extreme care to prevent damage to cable in trenching and relaying in the new trench. After cable has been removed from existing location, the trench shall be backfilled and compacted to the density of adjacent soil.

**667.03.2--Field Test for Cable Failure.** Field test for cable failure shall be as specified in Subsections 666.03.7 and 666.03.8.

**667.04--Method of Measurement.** Underground electric cable, removed and relaid, will be measured as provided in Subsection 666.04.

Excavation, sod and backfill will not be measured for separate payment but shall be included in the contract unit price per linear foot for electric cable-removed and relaid.

**667.05--Basis of Payment.** Underground electric cable, removed and relaid, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for excavation, removing existing cable and its protective covering; for excavating new trench; for laying cable as indicated on the plans; for backfilling old trench; for backfilling new trenches with selected sand, sand clay or clay gravel as indicated on the plans; for replacement of sod; for final cleaning up; and for all labor, equipment, tools, testing, and incidentals necessary to complete the work.

Payment will be made under:

667-A: Underground Electric Cable, Removed and Relaid - per linear foot

## **SECTION 668 - TRAFFIC SIGNAL CONDUIT**

**668.01--Description.** This work consists of furnishing conduit of specified materials and dimensions and installing them in accordance with these specifications and the details shown on the plans, or directed. It shall include the furnishing and installing of pull boxes, expansion joints, connections, and other items incidental to the completed work.

### **668.02--Materials.**

**668.02.1--General.** The materials used in this construction shall be of the type and size as indicated on the plans and shall meet the requirements indicated herein below.

**668.02.2--Conduit.** Conduit shall meet the requirements of Subsection 722.05.

**668.02.3--Pull Boxes.** Pull boxes shall be in accordance with the requirements of Subsection 722.06.

**668.02.4--Expansion Joints.** Expansion joints shall meet the requirements of Subsection 722.10.

**668.02.5--Miscellaneous Hardware.** Miscellaneous hardware shall meet the requirements of Subsection 722.11.

**668.02.6--Other Miscellaneous Materials.** Other miscellaneous materials shall meet the requirements of the appropriate Subsection(s) of Section 722.

**668.02.7--Granular Materials.** Granular materials for filling dry wells shall meet the requirements of Subsection 704.02.

**668.02.8--Concrete.** Concrete for encasement shall be Class B Concrete,



meeting the requirements of Section 804.

### **668.03--Construction Requirements.**

**668.03.1--General.** The following general requirements are applicable to all types of installation:

- (a) Where pull boxes are installed adjacent to poles, conduit between pull box and pole shall not be less than one and one-half inch size.
- (b) It shall be the privilege of the Contractor, at no additional cost to the State, to use larger size conduit if desired, and where larger size conduit is used, it shall be for the entire length of run from terminal to terminal. No reducing couplings will be permitted.
- (c) All conduits entering any and all concrete foundations, etc., shall have an approved weatherproof type of threaded union coupling or fitting outside concrete for future maintenance needs.
- (d) All conduit ends shall be capped with standard conduit caps until wiring is started. When caps are removed from rigid metal conduit, the ends shall be provided with approved conduit grounding bushings.
- (e) The location of all conduit placed for future electrical circuits shall be marked by a symbol at least three inches high cut into the pavement, face of curb, gutter or wall, directly above the conduit.
- (f) Conduit bends, except factory bends shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used conduit shall be bent, without crimping or flattening, using the longest radius practicable.
- (g) Conduit runs shall not exceed 420 feet in length unless otherwise indicated on the plans.
- (h) Conduit runs shown on the plans are for bidding purposes only, and may be changed with permission of the Engineer to avoid underground obstructions. A change order may be authorized if conduit runs can be made on opposite side of street to that shown on plans, in order to avoid obstructions and inconvenience to traffic. Final location of conduit shall be shown on the final as-built plans.

**668.03.2--Underground Traffic Signal Conduits.** The following requirements are applicable to underground installations:

- (a) Rigid metal conduit stubs, caps and exposed threads, as well as any point along the surface of the conduit that may have been injured in handling or installation, shall be painted with a good quality of asphalt, bituminous, or other paint suitable for the purpose. Where conduit is laid in cinders or gravel, it shall be enclosed in a two-inch jacket of concrete.
- (b) Conduit shall be laid to a depth of not less than 18 inches below the curb or curb and gutter grade in the sidewalk areas, and to a depth of not less than 30 inches below the finished grade in all other areas, except under

railroad tracks where it shall be not less than 36 inches below bottom of tie.

- (c) All pull boxes and splice boxes shall have drainage facilities provided in them.
- (d) Rigid metal conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed. Jacking and drilling pits shall be kept two feet clear of the edge of any type of pavement wherever possible. Excessive use of water that may cause undermining of the pavement will not be permitted. Excavation and backfill incidental to the operation will not be paid for separately.
- (e) Conduit terminating in pole or pedestal bases shall extend approximately two inches above the foundation vertically, or shall be sloped toward the handhole opening. Conduit entering through the bottom of a pull box shall be located as near the sides and ends as possible to leave the major portion of the box clear. Conduits shall ride freely through boxes for allowance of expansion and contraction.
- (f) Where it is deemed inadvisable to install expansion fittings in closely confined areas, the Engineer may permit the installation of approved bronze flexible tubing instead; expansion joints and tubing shall be the same size as the conduit.
- (g) Conduit entering controller cabinets shall be sealed to prevent the entrance of gases, using paraffin or other approved sealing compound as directed by the Engineer.
- (h) Before placing electric cable in existing rigid metal or rigid nonmetal conduit the conduit shall be cleaned with compressed air and rigid metal conduit shall also be cleaned with a mandrel.
- (i) Roll pipe conduit shall be installed in accordance with the requirements set forth herein, as per the manufacture's recommendations, or as directed by the Engineer.

### **668.03.3--Installation. Types III and IV**

**668.03.3.1--Trimming.** All cut ends shall be trimmed inside and outside to remove rough edges.

**668.03.3.2--Joints.** All joints between lengths of conduit, couplings, fittings and boxes shall be made by a method specifically approved for the type conduit being used.

**668.03.3.3--Supports.** Rigid nonmetallic conduit when installed above ground shall be adequately supported as required in Table II. In addition, there shall be a support within four feet of each box, cabinet, or other conduit termination.

**TABLE II**  
**SUPPORT OF RIGID NONMETALLIC CONDUIT**

Conduit Size, Inches	Maximum Spacing Between Supports, Feet	
	Conductors Rated 60°C and Below	Conductors Rated More than 60°C
½ - ¾	4	2
1 - 2	5	2½
2½ - 3	6	3
3½ - 5	7	3½
6	8	4

**668.03.3.4--Expansion Joints.** Expansion joints shall be provided where required to compensate for thermal expansion and contraction.

**668.03.3.5--Bends.** Bends shall be made so that the conduit will not be injured nor shall the internal diameter of the conduit be reduced. Field bends shall be made only with bending equipment specifically intended for the purpose being used.

**668.03.3.6--Use Permitted.** Type III and IV Polyvinyl Chloride (PVC) Conduit may be used under ground or above ground.

Type III shall be for encasement burial in concrete and Type IV shall be for direct burial with or without encasement.

**668.03.4--Aerially Supported Traffic Signal Conduits.** The following requirements are applicable to aerially supported installations:

- (a) Conduit entering pull boxes shall terminate two inches inside of the box wall and not less than two inches above the bottom. Conduit entering through the bottom of a pull box shall be located as near the sides and ends as possible to leave the major portion of the box clear. Conduits shall ride freely through boxes for allowance of expansion and contraction.
- (b) Expansion fittings as detailed on bridge structure plans shall be installed where conduit crosses an expansion joint in the structure. Where it is deemed inadvisable to install expansion fittings in closely confined areas, the Engineer may permit the installation of approved bronze flexible tubing instead; expansion joints and tubing shall be the same size as the conduit.
- (c) All assemblies on concrete structures shall be grounded through a bonding jumper to the rigid metal lighting conduit, which in turn shall be bonded to the steel superstructure or run to the ground.
- (d) All conduit, junction boxes, pull boxes, etc., must be attached to bridge

structures by means of studs driven by approved methods.

- (e) Aerial conduit shall be supported by messenger cable suspended from approved supporting devices when shown on the plans or directed.

**668.03.5--Testing Conduit.** After the completion of concrete work on fiber-lined concrete ducts, and before any cable is drawn into these ducts, each duct shall be tested with a round test mandrel of a size especially manufactured for the size of duct being tested. The mandrel shall be of the rigid type not less than 12 inches in length, and shall have tool steel cutting ends to remove concrete and other obstructions from the ducts. In conduit runs consisting of fiber-lined concrete duct and steel conduit combined, when it is impracticable to test with a rigid mandrel, tests shall be made with a flexible mandrel consisting of tool- steel discs mounted on a flexible wire rope. In all cases, ducts shall be thoroughly cleaned of water, sand and silt by drawing properly sized cylindrical brush through each duct as many times as necessary.

**668.04--Method of Measurement.** Traffic signal conduit of the type specified will be measured by the linear foot computed horizontally along the signal conduit, such measurement being made from the point of beginning to the point of termination of all sections of conduit, in trench, under roadways, or supported on structures. No extra length will be allowed for risers to controller cabinets, pole handholes, or pull boxes.

Jacking, drilling, excavating, backfilling and replacement of sod will not be measured for separate payment, but shall be incidental to and included in the contract unit prices for Direct Burial and Jacked or Drilled underground installations as applicable.

Messenger cable and other supporting devices for aerial supported signal conduit will not be measured for separate payment but shall be incidental to and included in the contract unit price for traffic signal conduit, aerial supported.

**668.05--Basis of Payment.** Traffic signal conduit, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing, laying, placing, forming, curing, connecting, supporting aerially, cleaning and testing all conduit, pull boxes, junction boxes not specified on plans or ordered, and incidental materials; for all excavating, backfilling, drilling and/or jacking necessary for subsurface installations; for replacing sod; encasement in concrete; final cleaning up; and for all labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

668-A: Traffic Signal Conduit, Underground, Type, Size - per linear foot

668-B: Traffic Signal Conduit, Underground Drilled or Jacked,  
Type, Size - per linear foot

668-C: Traffic Signal Conduit, Aerial Supported, Type, Size - per linear foot

668-D: Traffic Signal Conduit, Underground Encased in  
 Concrete, Type, Size - per linear foot

## SECTION 680 -- PORTABLE CONSTRUCTION LIGHTING

**680.01--Description.** Whenever the Contractor's operations are being conducted at night, the Contractor shall provide artificial lighting as may be necessary to provide for safe and proper construction and inspection of the work.

**680.02--Materials.** All lighting equipment will be furnished as required and retained by the Contractor after the work is completed. Material and/or equipment are not required to be new but shall be in good operating condition and in compliance with applicable safety and design codes.

The Contractor shall submit, for the Engineer's review and approval, a lighting plan showing the type and location of lights proposed for use during night work. The lighting plan shall be presented on standard size roadway plan sheets, 22" x 36", and on a scale of either fifty (50) feet or 100 feet to the inch. It shall clearly show the location of all lights necessary for every aspect of work to be done at night. In addition to the plan sheets, the Contractor shall submit catalog cuts giving the specific brand names, model numbers and ratings of the lighting equipment. The submittals shall include power ratings and photometric data. The Contractor shall allow fourteen (14) days for the Engineer to review the submittals. Night work shall not begin without the Engineer's approval of a lighting plan and the indicated lighting equipment and/or materials being in operation.

The Contractor may be required to take lighting level measurements in the presence of the Engineer at locations designated by the Engineer to verify compliance with the approved lighting layout submittals. Field light level measurements shall be equal to or exceed light levels on the submittal.

**680.02.1--Tower Lights.** A tower light shall consist of mercury vapor, metal halide or high pressure sodium fixtures mounted on a tower approximately thirty (30) feet in height. The tower light fixtures shall be heavy duty flood, area, or roadway style with wide beam spread. The tower shall be sturdy and free-standing without the aid of guy wires or bracing. The power supply shall be of sufficient capacity to operate the light(s) and shall be located for the shortest safe routing of cables to the fixtures.

Tower lights shall be of sufficient wattage and/or quantity to provide an average maintained horizontal luminance in accordance with the work to be done. See Subsection 680.02.3 for recommended light levels.

In no case should the main beam of the light be aimed higher than 60° above straight down. The lights should be set as far from traffic as practical and aimed in the direction of, or normal to, the traffic flow.

**680.02.2--Machine Lights.** All moving equipment used during night time operations shall have a mounted lighting system and flashing amber light on the equipment. In lieu of a flashing amber light, the Contractor may install four square feet of approved reflective material on the equipment in a location that will be seen by the traveling public. This lighting system shall illuminate the work area in each direction of travel of the equipment. Machine lights shall be mercury vapor, metal halide, high pressure sodium or low pressure sodium conventional roadway enclosed fixtures mounted on supports attached to the construction machine at a height of approximately thirteen (13) feet. The power supply shall be of sufficient capacity to operate the light(s) and shall be securely mounted on the machine. Electrical grounding of generators to frames of machines on which they are mounted shall be done in conformance with the National Electrical Code (NEC).

The machine light fixtures shall be of sufficient wattage and/or quantity to provide an average maintained horizontal luminance in accordance with the work to be done. See Subsection 680.02.3 for recommended light levels. Machine lights are in addition to conventional automotive type head lights which are necessary for maneuverability.

To avoid distraction to motorists, do not operate the flashing lights on equipment working outside the clear zone or behind traffic control devices.

**680.02.3--Lighting Levels.** The lighting plan submitted shall indicate how the Contractor intends to accomplish the lighting of the work area(s). Work areas shall be classified into one (1) of the following categories depending on the type of work to be accomplished:

CATEGORY I - Category I work areas will be lit to five foot-candles (5 fc). This category of work includes general work zone safety and visual tasks with large objects.

CATEGORY II - Category II work areas will be lit to ten foot-candles (10 fc). This category of work includes work around all construction equipment and visual tasks that require greater accuracy such as inspection of paving and resurfacing activities.

CATEGORY III - Category III work areas will be lit to twenty foot-candles (20

fc). This category of work includes activities that require the highest visual efficiency. These tasks present higher levels of visual difficulty and require significant attention from the observer, such as crack and pothole filling, joint sealing, critical connection and maintenance involving electrical connections and moving mechanical parts.

Lighting equipment shall be placed so the uniformity ratio, average maintained to minimum, shall not be greater than 10:1.

**680.03--Construction Requirements.** Tower lights may be used when the night work is confined to a fairly small area and is essentially a stationary operation.

Machine lights may be used when the night work is not confined to a small area and is essentially a continuous moving construction operation.

Tower lights may be provided in lieu of machine lights upon approval by the Engineer. Use of tower lights in lieu of machine lights will be considered when the number of machines, type of work, or need for inspection justify their use as decided by the Engineer.

The work area where traffic control devices are being set up or repositioned at night shall be illuminated.

The illuminated work area shall be large enough so that the movements of all personnel and equipment engaged in the work will be contained in the area.

The Contractor shall provide sufficient fuel, spare lamps, generators, and personnel qualified to operate the lights to assure that they will be maintained in operation during night work.

Existing roadway lights shall not eliminate the requirement for the Contractor to provide lighting. Consideration may be given to the amount of illumination provided by existing lights in determining the wattage and/or quantity of lights to be provided, if noted in the Contractor's submitted lighting plan.

**680.04--Method of Measurement.** Portable construction lighting, by tower and/or machine lighting systems, will be measured for payment only when a pay item for portable construction lighting is included in the contract. Otherwise, portable construction lighting will be considered incidental to other contract items and no direct payment will be made.

When payment for the portable construction lighting is provided in the contract, measurement will be made at the contract lump sum price. Partial payments for this pay item will be made as follows:

1. 50% of the lump sum price on the first monthly estimate after using the

lighting system.

2. 25% of the lump sum price on the first monthly estimate made after the project is 50% complete.
3. 25% of the lump sum price on the first monthly estimate after the completion of all scheduled night work.

**680.05--Basis of Payment.** Portable Construction Lighting, as measured above, shall be paid for at the contract lump sum price, which price shall be full compensation for furnishing, operating and maintaining everything necessary to provide a portable construction lighting system.

Payment will be made under:

680-A: Portable Construction Lighting

- lump sum

## **SECTION 681 - ROADWAY LIGHTING SYSTEM**

**681.01--Description.** This work consists of furnishing; installing, testing, erecting, constructing and assembling all materials to insure a properly operating roadway lighting system in accordance with the plans and specifications.

### **681.02--General Provisions.**

**681.02.1--Tests and Inspection.** The complete job shall be, during and/or after construction, subject to the supervision of the Engineer. Inspections and tests shall be conducted by the Engineer or in the presence of the Engineer prior to acceptance of the project and shall consist of the following tests:

- (1) Upon written notice, the Contractor shall furnish two men, one to include the job foreman, and tools to assist and be directed by the Engineer for a period of time required to make such tests and inspections as are requested by the Engineer pertaining to the safety and operation of any devices or system installed.
- (2) Insulation break-down tests with a megaohm meter shall be conducted on each and every circuit. Results of the tests shall meet minimum requirements for such tests set up by the latest edition of U.L. Standard 83. All readings shall be made in the Engineer's presence and a written report of same submitted to the Engineer upon completion of these tests.
- (3) The ground resistance of each ground rod and grounding system shall be measured. The resistance and soil conditions at the time the measurements were made shall be recorded and a report shall be submitted to the Engineer for approval. Ground-resistance measurements shall be made in normally dry weather, not less than forty-eight (48) hours after rainfall, and with the ground under test isolated from other grounds. Ground resistance shall also be measured from each



piece of equipment to the ground electrode. The ground rods and grounding system shall meet the requirements of the National Electrical Code (NEC). The Contractor shall be required to correct any deficiencies prior to acceptance of the system.

- (4) The Contractor shall be required to demonstrate in the presence of the Engineer, the operation of each and every device installed. This shall include, but not be limited to, all winches, latching devices, photocells and circuit breakers.
- (5) The Contractor may be required to take lighting level measurements in the presence of the Engineer at locations designated by the Engineer to verify compliance with the approved lighting layout submittals. Field light level measurements shall be equal to or exceed light levels on the submittal.

After completion of all tests, the Contractor shall request a semi-final electrical inspection. After this inspection and when all discrepancies have been corrected, the roadway lighting system shall be placed in operation for a satisfactory performance period. Final electrical inspection will not be made until the entire roadway lighting system has operated satisfactorily for a period of not less than fourteen (14) consecutive days, during which period(s) contract time will continue to be evaluated. During each fourteen (14) day performance period, if any failure should occur in any of the mechanical or electrical equipment in the system other than minor readily replaceable components, such as light bulbs, etc., the cause of the failure shall be determined, the necessary replacements made and the system operated satisfactorily for an additional period of not less than fourteen (14) consecutive days.

Upon completion of all work on the project and the satisfactory completion of the fourteen (14) day performance period on the roadway lighting system, the Contractor may request a final inspection of the project. If all items of work, excepting the completion of the Contractor's warranty period on the roadway lighting system, are considered satisfactory and acceptable, the Contractor may be given a partial maintenance release. This partial maintenance release is to relieve the Contractor of responsibility, except as stated in the roadway lighting system material warranty section, from maintenance on all other items of work on the project during the warranty period on the roadway lighting system. If the minimum 6-month warranty period has expired on the day of final inspection, this partial maintenance release is to relieve the Contractor of responsibility from maintenance on all items of work on the project.

During final inspection or upon completion of the warranty period after the final inspection, the Contractor shall request an inspection of the roadway lighting system. If this work is considered satisfactory and acceptable, the Contractor may be given a full maintenance release.

Payment of the final estimate releasing the remaining retainage will not be made

until after final acceptance of the project.

No additional time will be allowed for any additional performance period(s) found to be necessary because of failure(s) during the initial period, or subsequent performance period(s).

Acceptance will be for the entire roadway lighting system, no parts of the system will be accepted separately.

**681.02.2--Material Warranty.** The following Contractor warranty stipulations are in addition to those covered by Subsection 106.01.2 of the Standard Specifications.

All roadway lighting equipment and related components shall be fully operational at the final inspection of the project.

The Contractor shall warrant and guarantee all roadway lighting equipment and related components for a minimum period of six (6) months. This warranty period may begin after the day of partial release from maintenance or at the start of continuous use as referenced in Subsection 681.02.8. Regardless of when the warranty period begins, the Contractor shall warrant and guarantee the roadway lighting equipment and related components (1) at least up to and including the day of final inspection and (2) during the Contractor's warranty period. Final acceptance will not be made until after the warranty period expires.

It is the intent of the preceding paragraph to provide for equipment which performs as intended by the manufacturer. It is the further intent to obtain from the Contractor a level of workmanship which will assure the Department of an operational system devoid of Contractor laxities. Failure to perform as indicated shall require the Contractor to replace in kind or repair, the equipment or workmanship in question at no additional cost to the State. All materials and labor cost resulting from the replacement or repair of equipment or correction of poor workmanship shall be borne by the Contractor.

The Contractor shall not be responsible for outages occurring during the warranty period due to vandalism, traffic accidents or any problem not related to materials or workmanship. The Contractor will be required to make the necessary repairs but the cost of such repair shall be borne by the Department.

All manufacturer's standard warranties or guarantees on all electrical and mechanical equipment which are provided as customary trade practice shall be delivered to the Engineer at the final inspection. All warranties and guarantees shall be made out to the MDOT.

**681.02.3--General Information.** Plans are diagrammatic and care shall be exercised to install all electrical work in a manner which shall function in

accordance with plans, specifications and manufacturer's recommendations.

Exact location of all equipment shall be determined from dimensions on the plans, manufacturer's shop plans, or as directed by the Engineer.

Conduit runs, cable runs and circuit groupings are indicated diagrammatically with number of conductors shown in each run to clarify the operation and function of the system. The Contractor shall provide the number of conductors and conduits to produce an operative system as specified herein.

All materials shall be new and of equal or superior quality to those specified. All equipment or materials shall conform to the latest requirements and/or additions to the Underwriter's Laboratories, National Electrical Code, or National, State or local agency having jurisdiction.

All materials, devices, equipment, etc. shall be installed, tested, and connected in strict compliance with the manufacturer's recommendations, and, where specified, under the direct supervision of a manufacturer's representative.

All materials, devices, equipment, lighting, etc. shall be installed as required by the plans, specifications and manufacturer's recommendations. The Contractor shall use only experienced labor to do all trenching and jacking.

All equipment and apparatus furnished shall be protected from damage by the Contractor. All items marred or damaged shall be replaced or repaired to the complete satisfaction of the Engineer solely at no additional cost to the State.

Any piece of equipment, switch, device, etc. shown to be mounted on and/or adjacent to any existing equipment, which if installed may impair the proper operation of that equipment, shall be moved by the Contractor as required in order that existing equipment shall function properly. The Engineer shall be notified if any such condition exists.

It shall be the responsibility of the Contractor to provide training in the operation and maintenance of all parts of the roadway lighting system to any person, or persons designated by the Engineer. The training shall consist of a minimum of eight (8) hours of on-site instructions and shall be conducted near the end of completion of all work, but prior to final acceptance of the project.

The Contractor shall furnish the Engineer three (3) bound sets of the manufacturer's publications relating to the installation, operation and maintenance of all component parts of the roadway lighting system. The Contractor shall maintain a complete and accurate set of as-built plans throughout the project. At the final inspection, one (1) set each of full scale and 1/2 scale as-built blueprints shall be furnished to the Engineer.

The Contractor shall submit eight (8) copies of a letter of certification from the high mast manufacturer on manufacturer's letterhead, certifying that all of the lowering devices, poles and luminaires have been installed in accordance with the manufacturer's guidelines.

As referenced in Section 683 regarding high mast lighting assemblies, the following shall be provided from the same manufacturer.

- (1) Poles
- (2) Lowering Devices
- (3) Luminaires
- (4) Anchor Bolts
- (5) Portable Power Unit

The Contractor will be responsible for all power costs including deposits, customer charges, connection cost, etc. associated with roadway lighting system. The Contractor shall provide all electrical power required for construction, tests, satisfactory performance period(s), and usage up to and including the day of the final inspection of the system. Beginning on the day after the final inspection all power and related cost will be paid by the Mississippi Department of Transportation. The Department may assume power cost prior to the final inspection if the requirements of Subsection 681.02.8 are met.

All lamps shall be from the same manufacturer.

**681.02.4--Corrosion Protection.** It is the intent of these specifications to have all joints, connections, etc. completely water and moisture tight.

**681.02.5--Coordination of Existing Utilities.** It shall be the responsibility of the Contractor to coordinate work near all existing utilities, both overhead and underground, and to verify utility locations with the various utilities companies prior to commencing any work. Failure to do this shall not relieve the Contractor of any responsibility and will not be justification for requesting additional money from the MDOT due to damage of any of these utility lines.

**681.02.6--Removal of Salvaged Material and Debris.** It shall be the responsibility of the Contractor to have all salvaged materials, debris, etc. resulting from the Contractor's operations completely removed from the project site continually during construction.

**681.02.7--Initial Power Cost.** The Contractor will make all application and contacts necessary to obtain power from the local utility company. All cost relating to obtaining, providing, using of electrical power during the entire life of the contract will be absorbed by the Contractor, with exception noted in Subsection 681.02.8.

**681.02.8--Operation of the System.** After the final electrical inspection is completed and all noted deficiencies have been corrected, the system may be placed in operation at the request of the Engineer. This shall be accomplished before the complete removal of any temporary lighting system. When the system is placed into operation at the request of the Engineer, the Department will begin assuming all power costs. The Contractor will submit to the Department, original bill(s) received from the Utility Company after the day the Department assumed the power cost. The Department will pay for only the cost of power used during and after that billing period.

The Contractor will continue to warrant and maintain the system up to and including the day of final inspection.

The date the system is placed in operation at the request of the Engineer, shall be considered the commencement of the warranty period, otherwise material warranties will be in accordance with Subsection 681.02.2.

**681.03--Codes and Standards.** The Contractor shall strictly comply with the latest edition of the National Electrical Code, Federal, State or local codes having jurisdiction and shall notify the Engineer of any conflict between any of these codes and the plans and/or specifications before bid date or correct same at no additional cost to the State.

The following Codes shall be complied with in each and every respect as though fully written herein:

- (1) Latest Edition - National Electrical Code
- (2) Latest Edition - National Electrical Safety Code
- (3) AASHTO Requirements, Latest Edition, thereof

**681.04.2--Basic Materials and Methods.** The Contractor shall submit to the Engineer eight (8) copies of submittal data for all electrical materials and equipment proposed for use not later than twenty (20) days after the date of the Notice to Proceed and prior to beginning any work.

Refer to Subsection 105.01 of the Standard Specifications for explanation of the Engineer's authority with respect to materials furnished.

Before purchasing any equipment, the following materials shall be submitted to the Engineer for approval: Eight (8) copies of shop plans, computerized lighting layouts, test reports, and design calculations, showing overall dimensions, bus sizes, bussing diagrams, lug sizes, equipment rating, lighting levels on the roadway and all other pertinent information for the following items:

- (1) Lighting Controller
- (2) Wire and Cable

- (3) Conduit, Fittings and Pull Boxes
- (4) Luminaires
- (5) Wiring devices
- (6) Lamps
- (7) Poles
- (8) Lowering devices
- (9) Portable electric power unit
- (10) Breakaway bases
- (11) Ground Rods
- (12) Safety Switches
- (13) Hardware
- (14) Miscellaneous items as shown on the plans and/or stated herein

The Contractor shall provide manufacturer's in-use history data on the following items:

- (1) Luminaires
- (2) Poles
- (3) Lowering devices
- (4) Lowering devices - power unit

Shop plans for poles and breakaway devices shall include conformance certification that the device meets or exceeds the latest AASHTO standards. Information must also include all bolt torque requirements for anchor bolts and breakaway device bolts.

This data shall include a minimum of two (2) recently completed installations, a minimum of five (5) installations that have been in-place five (5) or more years; also, provide the name and address of the owner of each installation. The data shall be submitted with shop plans.

Reinforcing steel shall comply with Section 711 of the Standard Specifications.

Concrete shall comply with Section 804 of the Standard Specifications.

## **SECTION 682 - ELECTRICAL DISTRIBUTION SYSTEM**

**682.01--Description.** In addition to the requirements set forth in Section 681, the electrical distribution system generally will consist of the secondary electrical service, grounding and bonding system, secondary distribution and secondary power controller.

The secondary electrical service shall be 480 volts, 1 phase, 3 wire, 60 HZ, unless indicated otherwise on the plans. The overhead service entrance shall have five (5) feet of tailwire extension from the service entrance cap for

connection to the Utility Company's overhead transformer service facilities. An underground service entrance shall consist of conduit and wire placed, after coordination with the serving utility, in a manner to connect the secondary power controller with the ground mounted transformer. The system will be metered as per serving utility company's requirements.

Bonding and grounding of all electrical service equipment enclosures and ground terminals shall be as shown on the plans and/or in accordance with Article 250 of the National Electrical Code.

The secondary distribution shall consist of furnishing, installing, erecting and laying electrical branch circuits. All branch circuits shall be buried underground except where shown otherwise on the plans. Branch circuits shall consist of conduit, conductors, connectors, and all hardware necessary to complete the work. Pull boxes and junction boxes may be both underground and/or structure mounted.

The secondary power controller shall consist of a lighting controller for control of roadway lighting, enclosure, conduit with fittings, wire, devices, ground rods, photocell, and miscellaneous hardware. The controller shall have a dead front behind outer doors with only breaker handles, hand-off automatic selector switch and receptacle exposed. All controllers shall be labeled with a phenolic engraved label having 1/4-inch white letters on a black background. Example: "SPC#1".

## **682.02--Materials.**

**682.02.1--Secondary Distribution.** The materials used in this construction shall meet the requirements of Subsection 723.02.

**682.02.2--Secondary Power Controller.** The materials used in this construction shall meet the requirements of Subsection 723.03.

## **682-03--Construction Requirements.**

**682.03.1--Grounding and Bonding System.** Where conduit enters an enclosure, a bonding type bushing shall be used on all conduits with #6 AWG copper bonding conductors bonded to all conduits thence to equipment enclosure or ground bus.

The green equipment grounding terminal of all grounding type equipment shall be bonded to its equipment ground conductor with a properly sized green bonding conductor.

One (1) green equipment grounding conductor shall be pulled into all raceways, sized the same as the branch circuit conductors, or as noted on the plans. This conductor shall be bonded to box ground terminals, pole ground terminal, ground

bus of panel, cabinet, enclosures, and/or ground electrodes shown on the plans.

**682.03.2--Secondary Distribution.** All trenching shall be performed by mechanical means and all sides shall be straight and vertical. Width of trenches shall not exceed eight (8) inches on either side of placed branch circuit conduits. All backfill shall be made with a friable material which has been approved by a visual inspection of the Engineer. The Contractor shall seed trenched areas as directed by the Engineer.

All conduits shall be sized as shown on the plans, or where size is not indicated, the Engineer shall be consulted. All conduits shall be run 2' 0" outside of roadway shoulder lines where practicable. All conduit field bends shall be made in accordance with the National Electrical Code, Article 344 for metallic conduit, or Article 352 for non-metallic conduit. All upturned conduits shall be plugged or ends taped to prevent entrance of debris or moisture. A dry swab shall be pulled through each conduit to remove any debris or moisture before pulling wire.

All flexible conduit shall be liquid tight with proper liquid tight fittings.

Conduit mounts exposed on poles or other supports shall be supported at 5' 0" on center by two (2) hole straps.

Only approved lubricants which will be not harm the conductor insulation shall be used while pulling wires. Each branch circuit shall be labeled with a permanent pressure-sensitive label with proper numbers and letters for identification.

All connections shall be made in pole bases and controller panels unless otherwise shown on the plans. Splices shall be made using compression type splice connectors. All splices and connections shall be well taped to provide an insulation equal in rating and thickness to the conductor insulation as follows:

- 1<sup>st</sup> layer - flame retardant, cold and weather resistant vinyl plastic tape.
- 2<sup>nd</sup> layer - self fusing, rubber-based insulating compound laminated to all weather grade PVC backing, rated up to 600 volts.
- 3<sup>rd</sup> layer - same as 1<sup>st</sup> layer.

No splices shall be allowed in pull boxes. All runs shall be continuous from controller to pole and from pole to pole. The Contractor shall be responsible for purchasing continuous lengths of wire to achieve the above.

Approved jacking or boring methods shall be used where a branch circuit must be placed under an existing roadway. Boring operations shall be kept a minimum of two (2) feet from the edge of shoulder, and care shall be taken not to disturb existing pavement or edge drains. The use of water, which could undermine



pavements, shall not be permitted. The jacking or boring site must be returned to its undisturbed state upon completion of the operation. Jacking or boring operations and other incidentals necessary to this operation will be cost of Underground Branch Circuit, Jacked or Bored.

Contractor may jack or bore, or trench at paved ditches encountered on branch circuit runs. Where paved ditches are trenched, all concrete must be replaced at no additional cost to the Department.

**682.03.3—Pull Boxes and Junction Boxes.** Pull boxes and junction boxes shall be installed in accordance with the plans. The location of the boxes may be adjusted to accommodate field conditions with the approval of the Engineer.

**682.03.4--Secondary Power Controller.** The secondary power control unit shall be installed in accordance with the plans and shall present a neat and workmanlike finished appearance. The Contractor shall cooperate with utility in completion of unit.

**682.04--Method of Measurement.**

**682.04.1--Secondary Distribution.** Branch circuits shall be measured by the linear foot. The measurement being computed as follows:

Jacked or Bored - Horizontally along the length of the jacked section of conduit.

Underground - Horizontally along the trench lengths.

Structure mounted branch circuit - horizontally or vertically along the length of the sections of conduit installed.

No extra length will be allowed for risers to lighting assemblies or secondary power controllers. The terminals for measurement of lengths will be considered specifically as the center of lighting assemblies, power controllers, and junction boxes. Payment for branch circuit connectors, tape, etc. shall be included in payment allowed for the total length of branch circuits.

Hardware, fittings, support devices, excavation, sod, backfill, seeding and other incidentals will not be measured for separate payment, but shall be included in the contract unit price per linear foot for branch circuits.

Pull boxes and junction boxes will be measured as a unit quantity per each as detailed on the plans.

**682.04.2--Secondary Power Controller.** Secondary power controllers complete in place will be measured as unit quantities per each, which shall include all items necessary to complete the installation.

**682.05--Basis of Payment.**

**682.05.1--Secondary Distribution.** Branch circuits of the type specified, measured as prescribed above, will be paid for at contract unit price per linear foot; which price shall be full compensation for furnishing, installing, connecting, and excavating, trenching, backfilling and replacement of sod; for hardware, fittings and support devices; for final clean-up; and for all labor, tools, equipment and incidentals necessary to complete the work.

Pull boxes and junction boxes, as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing, installing, and mounting; for hardware, fittings, supports; for final clean up; for labor, tools, equipment and incidentals necessary to complete the work.

**682.05.2--Secondary Power Controller.** Secondary power controllers, measured as prescribed above, will be paid for at the contract unit price per each, which price shall include all constructing, erecting, installing, testing, connecting, cleaning up and for all materials, equipment, labor and tools necessary to complete the work.

Payment will be made under:

- 682-A: Underground Branch Circuit, Size, No. of Conductors - per linear foot
- 682-B: Underground Branch Circuit, Jacked or Bored, Size,  
No. of Conductors - per linear foot
- 682-C: Structure Mounted Branch Circuit, Size,  
No. of Conductors - per linear foot
- 682-D: Type Pull Box - per each
- 682-E: Type Junction Box - per each
- 682-F: Secondary Power Controller - per each

**SECTION 683 - LIGHTING ASSEMBLIES**

**683.01--Description.** In additional to the requirements set forth in Section 681, lighting assemblies shall consist of high mast lighting assemblies, low mast lighting assemblies, underpass lighting assemblies and portable power units. High mast lighting assemblies shall consist of a pole, lowering device, luminaires, anchor bolts, lamps, and miscellaneous hardware. Low mast lighting assemblies shall consist of pole, arm, luminaire, anchor bolts, breakaway device,

lamp, and miscellaneous hardware. Underpass lighting assemblies shall consist of the luminaire, conduit box, lamp, fuses and miscellaneous hardware. The portable power unit shall consist of a heavy-duty industrial type reversible power unit, dry type transformer and hand held control unit.

### **683.02--Materials.**

**683.02.1--High Mast Lighting Assembly.** The materials used in this construction shall meet the requirements of Subsection 723.04.

**683.02.2--Low Mast Lighting Assembly.** The materials used in this construction shall meet the requirements of Subsection 723.05.

**683.02.3--Underpass Lighting Assembly.** The materials used in this construction shall meet the requirements of Subsection 723.06.

**683.02.4--Portable Power Unit.** The materials used in this construction shall meet the requirements of Subsection 723.07.

### **683.03--Construction Requirements.**

#### **683.03.1--High Mast Lighting Assemblies.**

**683.03.1.1--Field Assembly of All Components.** The pole section shall be fitted together and supported by blocks. The Contractor shall use the piece marks provided by the manufacturer. The proper joint overlap shall be provided and verified. The sections shall be lashed together by an approved method which will not damage galvanizing during erection. The wiring, lowering device, cables, and all components, except luminaires, shall be installed on the pole before erection, as per manufacturer's guidelines. No field welding is permitted on the pole shaft. Any damaged areas on the pole surface shall be coated with a zinc rich paint before erection.

**683.03.1.2-Setting and Aligning Poles.** The pole shall be lifted at a point as far above center of gravity as possible. The lifting shall be smooth, continuous and free of abrupt motions. The base shall be placed on pre-leveled nuts and supported by the crane until anchor bolt nuts are tightened. Cables or chains which may damage galvanizing shall not be tied to poles.

Poles shall be plumbed by the method shown on the plans. The plumbing shall be done early in the morning while minimum heat is affecting the pole and while there is no appreciable wind. After the pole is plumb, the anchor bolt nuts shall be tightened and secured against loosening by tightening the nuts until there is an abrading or coining of the base plate under the nut.

The space between the top of the foundation and the bottom of the base plate

shall be grouted a maximum of three (3) inches deep, making two (2) drainage openings with ¾-inch PVC pipe for internal condensate drainage.

**683.03.1.3--Cable Installation.** Care shall be taken to remove all twisting from hoisting cables before installation and/or operation of the lowering device.

**683.03.2--Low Mast Lighting Assemblies.**

**683.03.2.1--General.** All component parts of the low mast lighting assemblies shall be installed as per manufacturer's guidelines and this specification.

**683.03.2.2--Setting and Aligning Poles.** All wiring, luminaires, and other components shall be installed as per plans before pole erection. Poles shall be lifted into place on the foundation using preleveled nuts for alignment. All poles shall be as nearly plumb as possible.

**683.03.2.3--Alignment of Luminaires.** Luminaires shall be installed and aligned to provide the proper lighting pattern on the roadway. Pavement overhang shall be one (1) foot for bracket arm type assemblies or as shown on the plans. Post top mounted assemblies shall be properly aimed.

**683.03.3--Underpass Lighting Assemblies.** All component parts of the underpass luminaire shall be installed as per manufacturer's guidelines and the plans.

**683.03.4--Portable Power Unit.** The power unit shall be constructed in accordance with Underwriters Laboratories Standards and shall be so listed.

**683.10.4--Method of Measurement.** High mast and low mast lighting assembly, of the type specified, will be measured as a unit quantity per each, which measurement shall include the pole, lowering device, luminaires, lamps, pole wiring, conduit, anchor bolts, ground rods and all other items necessary to complete installation.

Underpass lighting assembly, of the type specified, will be measured as a unit quantity per each, which shall include luminaire, lamp, wiring, conduit box, fuse, and mounting hardware.

The portable power unit, complete in place, will be measured as a unit quantity per each, which shall include all items necessary to complete the unit.

**683.10.5--Basis of Payment.** High mast and low mast lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, and for all construction, placing, erecting, installing, connecting, and testing; for poles, lowering device, luminaires, lamps, breakaways, ground rods, conduits, cable,

wiring and all hardware; for final cleaning up; and for all equipment, labor, tools, and incidentals necessary for completion of the work.

Underpass lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials; for all construction, installing, connecting, and testing; for luminaires, lamps, conduit boxes, hardware, wiring, connectors, and miscellaneous hardware; for all tools, labor, equipment and incidentals necessary to complete the work.

Portable electric power unit, measured as prescribed above, complete and accepted, which price shall be full compensation for furnishing all equipment and materials; for power unit, transformer, attachment devices, remote control unit; and for all labor and incidentals necessary to complete the unit.

Payment will be made under:

683-A: Lighting Assembly, High Mast, <u>Type</u>	- per each
683-B: Lighting Assembly, Low Mast, <u>Type</u>	- per each
683-C: Lighting Assembly, Underpass, <u>Type</u>	- per each
683-D: Portable Electric Power Unit	- per each

**SECTION 684 - POLE FOUNDATIONS**

**684.01--Description.** In additional to the requirements set forth in Section 681, pole foundations shall be cast-in-place reinforced concrete pilings or driven piling of types and sizes detailed on the plans.

**684.02--Materials.** Concrete for pole foundations shall be Class "B" structural concrete.

All reinforcement steel shall be in accordance with Section 711 of the Standard Specifications. The sizes for the reinforcement shall be as shown on the plans.

Pilings will be in accordance with Section 719 of the Standard Specifications.

**684.03--Construction Requirements.** Pole foundations shall be constructed as per the details on the plans, these specifications and Section 803 of the Standard Specifications. Casings, as required, will be in accordance with Section 803 of the Standard Specifications.

Structure excavation for foundations shall be opened vertically in accordance

with Section 801 of the Standard Specifications. All reinforcement, conduits, and anchor bolts shall be set in place before any concrete is poured. Forming, casting, and curing shall be in accordance with Section 601 of the Standard Specifications.

Due to soil conditions in certain locations, as noted on the plans, concrete shall be placed with a tremie. When a tremie is used, it shall performed in accordance with the requirements in Subsection 804.03.9 of the Standard Specifications.

It may be necessary to used slip casing to keep the holes open. Casing will be required in portions of the holes that are not stable. Casings authorized by the Engineer shall be of suitable size and strength to accommodate the drilling equipment and to withstand ground-pressures and removal operations without deformation of the poured shaft. When removed, the casings shall revert to the Contractor for disposal.

**684.04--Method of Measurement.** Pole foundations of the size specified will be measured by the cubic yard, which measurement shall be the area bounded by the vertical planes of the neat lines of the foundation.

Slip casings will be measured by the linear foot from the ground elevation to the bottom of the strata needing to be cased.

Piling will be measured by the linear foot from the bottom of the pile to the top of the pile.

**684.05--Basis of Payment.** Pole foundations, measured as prescribed above, will be paid for at the contract unit price per cubic yard, which price shall include full compensation for concrete, structure excavation, and reinforcing steel; for placing, vibrating, curing, and installing; for final clean-up; and for all equipment, labor, tools and incidentals necessary to complete the work.

Slip casings, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for all materials, tools, equipment, labor, and incidentals necessary to complete to work.

Piling, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for all materials, tools, equipment, labor, and incidentals necessary to complete to work.

Payment will be made under:

- |                                       |                   |
|---------------------------------------|-------------------|
| 684-A: Pole Foundations, __" Diameter | - per cubic yard  |
| 684-B: Slip Casings, __" Diameter     | - per linear foot |

## SECTION 685 - TEMPORARY LIGHTING SYSTEM

**685.01--Description.** In addition to the requirements set forth in Section 681, a temporary lighting system shall consist of furnishing all materials, installing, erecting, constructing, and assembling same to insure a properly operating temporary lighting system in accordance with the plans and specifications. The work shall also include all maintenance associated with the completed lighting system, provision of service and electrical power for this system during the duration of the required lighting period, adjustment and relocation during traffic control phases and removal of the system at the completion of the required lighting period.

**685.01.1--General.** The Contractor shall make provisions with the serving utility company for all construction necessary by the utility for power service. It will be required that initial fees be paid to the utility for installation of wiring, transformers, cutouts, etc., before utility construction can begin.

The Contractor shall be responsible for repairing all malfunctions in the system due to equipment failure, vandalism, accidents, etc., including all parts, labor, equipment and incidentals necessary to maintain the system. The Contractor shall also be responsible for all utility company costs for removal of the service upon completion of the project at no additional costs to the State.

The system shall be in fully operating condition during all hours of darkness for the duration of the required lighting period.

All electrical materials and operations for complete and operative systems shall be as follows and hereinbefore specified.

Lighting systems complete with fixtures, lamps, poles, switches, conduits, and wiring shall be provided.

The Contractor shall provide for power requirements and final electrical connections to all lighting systems, relocations required by traffic control phasing and removal of systems at completion of project.

**685.01.2--Secondary Electrical Service.** The temporary lighting service shall be 240-Volt, 1-phase, 3-wire, 60-hertz or as noted on the plans.

The Contractor shall pay all costs for electricity required by the lighting system during the duration of the project at no additional cost to the State.

The system shall be metered. Meter base shall be of a type approved by serving

utility company. The Contractor shall pay all costs associated with system metering at no additional cost to the State.

**685.01.3--Removal of Materials.** Upon completion of the project in conjunction with removal of the temporary roadways and traffic control devices, the Contractor shall disconnect and remove the traffic control lighting system. All materials shall be the property of the Contractor.

The Contractor shall also be responsible for all costs incurred by the utility company for removal of utility company services.

**685.02--Materials.** Materials for temporary lighting systems shall meet the requirements of Subsection 723.08.

**685.03--Construction Requirements.** All component parts of the temporary traffic control lighting system shall be installed as shown on the plans and required by construction procedures.

**685.04--Method of Measurement.** Electrical cable of the type specified shall be measured by the linear foot. Measurement shall be computed horizontally from terminal to terminal along the circuits. No extra lengths will be measured for risers to lighting assemblies or any other terminals.

Temporary lighting assembly shall be measured as a unit quantity per each. Measurement shall include fixture, junction box, wiring, pole, ground rod, bracket, lamp and all other items necessary to complete the installation.

Service pole shall be measured per each. Measurement shall include pole, wiring, conduit, supporting devices, ground rod, hardware, safety switch, fuses, utility company service provisions, electrical power and all other items necessary to complete the installation.

**685.05--Basis of Payment.** Electrical cable, measured as prescribed above, will be paid for at the contract unit price per linear foot; which price shall be full compensation for furnishing, installing, connecting and testing and maintaining all materials; for supporting devices; for final clean-up; and for all labor, equipment, tools, and incidentals necessary to complete the work and for removal of materials upon completion of project.

Temporary lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials; for excavation, back-filling, replacing sod, and for all construction, placing, erecting, installing, connecting, testing, and maintaining; junction boxes for poles, brackets, luminaires including lamps and ballast, ground rods, conduits, hardware, cable, for adjustments, replacement of equipment or material which malfunctions, for final cleaning up; and for all



equipment, labor, tools, and incidentals necessary to complete the work, and for removal of materials upon completion of project.

Service pole, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials for all construction, placing, erecting, installing, connecting and testing; for utility company up/down costs, electrical power, pole, safety switch, wiring, fuses, conduit, ground rod, supporting devices and all hardware, for adjustments, replacement of defective equipment, for final clean-up equipment, labor, tools and incidentals necessary to complete the work, and for removal upon completion of the project.

Payment will be made under:

- 685-A: Underground Electric Cable, Type, AWG #,  
No. of Conductors - per linear foot
- 685-B: Aerially Supported Electric Cable, Type, AWG #,  
No. of Conductors - per linear foot
- 685-C: Temporary Lighting Assembly, Type - per each
- 685-D: Service Pole - per each

**SECTION 686 - RELOCATION OF EXISTING LIGHTING ASSEMBLIES**

**686.01--Description.** In additional to the requirements set forth in Section 681, relocation of existing lighting assemblies of the types indicated on the plans shall consist of removing and relocating pole, luminaire, providing new foundation and miscellaneous hardware. Wiring shall be reworked or replaced as directed below and on the plans.

**686.02--Materials.** Generally, all the materials needed to relocate the lighting assembly(ies) will be existing materials. The lighting assemblies, wire and foundations may be either permanent or temporary. Wiring, ground rods, bolts and other items shall be relocated as per the plans. Additional items necessary for a complete working lighting assembly shall be required whether or not mentioned in these specifications.

**686.02.1--Poles.** Steel poles are hot-rolled weldable grade steel, galvanized in accordance with ASTM Designation: A 123, length as indicated on the plans. Since the anchor bolt layout may vary from pole to pole, the Contractor shall field verify bolt circles of existing lighting assemblies.

Timber poles, used on temporary lighting systems, shall conform with the

applicable requirements of Section 685. Voids left by the removal of these poles shall be filled and compacted as directed by the Engineer.

**686.02.2--Luminaire.** Low mast luminaires are bracket arm mounted type, 250 or 400-watt, high pressure sodium. The Contractor shall verify luminaire lamp wattage that may be stated on the plans. High mast luminaires are 1000-watt high pressure sodium.

The Contractor will be required to install new 250-watt, 400-watt or 1000-watt clear high pressure sodium lamps as indicated on the plans.

The fixtures shall be cleaned and refurbished before re-installing. Any inoperative ballasts shall be replaced. The luminaire is to be in good working order when re-installed.

**686.02.3--Pole Foundations.** Pole foundations are cast-in-place concrete. The removal of the foundations shall be as detailed in other sections of the specifications.

New foundations shall be cast-in-place as per Section 684 or as per plans.

**686.02.4--Anchor Bolts.** The Contractor will be required to install new anchor bolts. Anchor bolts shall be galvanized as per ASTM Designation: A 123. The minimum yield strength of the anchor bolts shall be 50,000 psi. The new anchor bolts shall be of the same design as the existing bolts.

**686.03--Construction Requirements.** All component parts of the lighting assemblies shall be removed and relocated as shown on the plans and required by the new construction procedures. When an item is removed it shall be stored in a location approved by the Engineer. All items scheduled to be re-installed shall be safeguarded by the Contractor and shall be fully operational at the end of the project.

**686.03.1--Branch Circuit Wiring.** All existing wiring in place will be shown on the plans. The Contractor shall verify the type and size. For relocation and maintenance purposes, splicing of permanent wiring will not be permitted. New branch circuit wiring shall be provided as detailed on the plans.

Splices of permanent wiring are permitted in pole bases only. Temporary wiring may be spliced as needed. All wiring shall meet the requirements of the National Electrical Code (NEC).

The re-use of existing conductors and conduit when relocating permanent wiring will not be permitted. New conductors, conduit, boxes, connectors, etc. shall be provided as detailed on the plans. New wiring installation and materials shall be as per specified for underground branch circuit elsewhere in these specifications.

Temporary wire may be re-used as long as it meets the requirements of the NEC.

**686.03.2--Maintenance of Service.** The existing lighting system shall be maintained and kept in operation during the duration of the project. The Contractor shall provide and install any and all materials required to keep the lighting system in operation through the duration of the contract. Existing disconnected underground circuit conductors shall be cut off 24 inches below grade and abandoned.

**686.04--Method of Measurement.** Relocation of existing lighting assembly will be measured as a unit quantity per each. Relocation of existing wiring will be measured per linear foot.

**686.05--Basis of Payment.** Relocation of existing lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all new materials required, for excavation, backfill, sod replacement, construction, placing, reconnecting, and for testing; for all equipment, tools, labor, final clean up and incidentals necessary for completion of the work.

Relocation of existing wiring, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all material; for trenching, backfilling, disconnecting, reconnecting, replacing sod and for all construction, testing, installing, and for all conductors, conduit, J-boxes, connectors and miscellaneous materials; for final clean-up, tools, labor, equipment and incidentals necessary for completion of the work.

Payment will be made under:

686-A: Relocation of Existing Lighting Assembly - per each

686-B: Relocation of Existing Wiring - per linear foot

**SECTION 690 - DECOMMISSIONING OF ABANDONED  
OR UNUSED WATER WELLS**

**690.01--Description.** This work is applicable to abandoned or unused water wells over 25 feet deep and shall consist of plugging with portland cement grout the aforementioned water wells in accordance with current, as amended, Surface Water and Ground Water Use and Protection Regulations issued by the State of Mississippi Department of Environmental Quality, Office of Land and Water Resources. The work shall be performed by a water well Contractor so licensed by the State of Mississippi.

The preliminary plan quantity for this item of work is based on a theoretical yield

of 1.213 cubic feet of grout per bag of portland cement and an estimated depth of 300 feet for each of the wells.

Well locations shall be adequately marked by the Contractor prior to clearing and grubbing. The markings shall be maintained during construction.

Water wells in addition to those listed in the plans may be discovered on the project during the course of construction. The Contractor shall decommission any additional wells with payment made at the contract unit price bid for Grouting Abandoned Water Wells.

**690.02--Materials.** The materials used in this construction, when sampled and tested in accordance with Subsection 700.03, shall meet the requirements of the following Subsections:

Portland Cement .....	701.01, 701.02 & 804.02.5
Water .....	714.01.1 & 714.01.2

**690.02.1--Grout Mix Design.** The grout mixture shall be composed of one bag (94 lbs.) of portland cement to 5½ gallons of water.

**690.03--Construction Requirements.** The abandoned or unused water wells shall have obstructions removed from the well casing prior to grouting.

The casing shall be pulled or reamed. If the casing cannot be removed and unless it is known that the annular space was grouted during construction of the well, then the casing shall be perforated and grout shall be forced under pressure into the annular space during the plugging operation.

Casing not removed shall be cut off a minimum of three (3) feet below finish subgrade elevation, finish slope elevation or natural ground, whichever is applicable, depending on the location of the well with regard to the roadway typical section at the well site.

The well shall be grouted from the bottom of the hole to the top of the cut off casing for instances where the casing is not removed and from the bottom of the hole to three (3) feet below finish subgrade elevation, finish slope elevation or natural ground, whichever is applicable, for instances where the casing is removed.

Free-fall placement of grout is prohibited.

The Haliburton Method, which consists of forcing grout under pressure, from inside the casing, out the bottom and up the outside of the casing, filling the annular spaces and at the same time, filling the casing, is considered an acceptable alternate method to that otherwise indicated herein for the grouting

operation associated with decommissioning water wells.

When the Haliburton Method is proposed for use, the Contractor shall furnish the Project Engineer with the details of this method prior to performing the work.

Excavations made in association with this work shall be backfilled and compacted following completion of plugging operations.

Within thirty days after completion of the plugging operation, the Contractor shall complete a Well Decommissioning Form and submit copies to the Office of Land and Water Resources and to the Mississippi Department of Transportation Project Engineer. Well decommissioning forms are available from the Office of Land and Water Resources.

**690.04--Method of Measurement.** Grouting abandoned water wells will be measured by the pound of portland cement incorporated into the grout mixture used to plug the well.

Water incorporated into the grout mixture will not be measured for separate payment.

**690.05--Basis of Payment.** Grouting abandoned water wells will be paid for at the contract unit price per pound of portland cement incorporated into the grout mixture used to plug the well, which price shall be full compensation for furnishing materials to be incorporated into the specified grout mixture; for all hauling, mixing, placing, and clean-up required to plug the well; for removing obstructions from the casing; for pulling and disposing of, reaming or perforating the casing as required; for the cutting off and disposal of cut off casing; for removal and disposal of water pipe, well pump, water tank, electrical wiring or other miscellaneous obstructions at the site; for excavation, backfill and compaction associated with this work; and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

690-A: Grouting Abandoned Water Wells - per pound

**SECTION 699 - CONSTRUCTION STAKES**

**699.01--Description.** This work consists of performing all calculations and other work necessary to establish and/or verify all horizontal and vertical control data; and furnishing, placing and maintaining roadway construction stakes or bridge construction stakes, or both, necessary for the proper prosecution of all features and items of the work under contract. This shall include, but not be limited to, grades and drainage structure locations, lengths, elevations and skews. When the

contract includes a pay item for roadway construction stakes as provided herein, any references in other sections of the Standard Specifications to establishment of control points or construction staking "by the Department" shall be construed to mean "by the Contractor".

**699.02--Materials.** The Contractor shall furnish all personnel, materials, equipment and devices necessary for determining, establishing, setting, checking and maintaining points, lines, grades and layout of the work. All surveying equipment shall be properly adjusted and suited for performing the work required. Traffic control necessary for the proper execution of the work shall be furnished by the Contractor without separate measurement for payment. Stakes shall be of sufficient length, thickness and quality to serve the purpose for which they are being used.

**699.03--Construction Requirements.** The Department will establish, one time only, reference points and bench marks at distances not to exceed 1000 feet for roadway work. For bridge work, the Engineer's field control will consist of a stationed baseline reference point near each end of the bridge(s) and one accessible bench mark near each bridge site. For the purpose of determining responsibility for construction stakes, lines and grades, a box bridge will not be considered as a bridge. The Contractor shall verify the accuracy of the control points before proceeding with the layout for construction.

When errors are discovered and control points do not agree with the plans, the Contractor shall promptly notify the Engineer in writing, and explain the problem in detail. The Engineer will advise the Contractor within five (5) working days of any corrective actions which may be deemed necessary.

The Contractor will be responsible for verifying and modifying, as necessary to best fit existing field conditions, lengths, locations, elevations and skew angles of all drainage structures shown on the construction plans. All junction box and inlet locations and heights shall also be verified and modified as necessary to fit existing field conditions. Modifications to the plans shall not be made without the consent of the Project Engineer. The Contractor will not be responsible for determining the size of drainage structures, but should immediately report any suspected error to the Engineer. Heights of fill over drainage structures shall be checked to verify class of pipe, bedding and the appropriate standard and/or modified standard drawing(s) required in the construction with any differences from the plans being reported to the Engineer.

The Contractor shall perform work necessary to verify alignment and plan grades on all roadway intersections and tie-ins. Any discrepancies in grades, alignment, location and or dimension detected by the Contractor shall immediately be brought to the attention of the Project Engineer.

The Contractor shall employ sufficient qualified personnel experienced in

highway surveying and layout to complete the work accurately. The Contractor shall also determine and provide all additional grade controls and staking operations necessary to secure a correct layout and construction of the work. All minor variations in layout and grades required to meet field conditions shall be resolved with the Engineer and shall not be considered justification for adjusting contract price or time.

Examples of minor variations in layout and grades are:

- (a) Adjustment of drainage or other structure length, alignment, and flow line elevation.
- (b) The adjustment of grades and alignment at roadway intersections, cross-overs, railroad crossings, interchanges, existing bridges and roadways.
- (c) Adjustment of curve data.

The Contractor will be responsible for calculating and laying out all additional lines, grades, elevations and dimensions necessary to construct the work required in the plans. All grades and other layout data computed by the Contractor shall be recorded and a copy of this data shall be furnished, with sufficient time for checking, to the Engineer before field work is started. The originals of all data shall be furnished to the Engineer on or before final inspection for the Department's permanent file. The Contractor shall also furnish personnel to assist the Engineer in taking stringline or other notes to determine whether specified tolerances are met. Any inspection or checking of the Contractor's layout by the Engineer and the approval of all or any part of it will not relieve the Contractor of the responsibility to secure proper dimensions, grades, and elevations of the several parts of the work.

Prior to beginning construction on any structure which is referenced to an existing structure or topographical feature, the Contractor shall check the pertinent location and grades of the existing structures or topographical features to determine whether the location and grade shown on the plans are correct.

The Contractor shall stake centerline control at each station, BOP, EOP, PC, PT, SC, CS, TS, ST, and equations just before field cross sectioning by the Department for both original and final cross sections.

The Contractor shall furnish "as built" finish centerline elevations to the Project Engineer prior to final inspection of the project.

The Contractor shall set stakes and/or flags on the right-of-way line at each station and right-of-way break or as directed by the Engineer before clearing operations are started on any section of roadway.

On grading projects, the Contractor shall set slope stakes at each station and at the beginning and end of spirals and curves. Closer intervals will be required for sharp changes in grades or alignment, widening and certain other geometric details.

The Contractor shall set subgrade blue tops on centerline, break points and at the left and right subgrade shoulder lines at intervals of not more than 100 feet on tangents and intervals of not more than 50 feet in curves. Closer intervals will be required for sharp changes in grades or alignment, widening, or super elevation.

On paving contracts, the Contractor shall set subgrade, base and paving blue tops. The base and pavement blue tops shall be set on intervals in accordance with the appropriate applicable requirements of Sections 321, 403 and 501.

The Contractor shall exercise care in the preservation of stakes and bench marks and shall reset them when they are damaged, lost, displaced or removed. The Contractor shall use competent personnel and suitable equipment for the layout work required and shall provide that it be performed under the supervision of, or directed by, a Registered Professional Engineer or Registered Land Surveyor who is duly registered and entitled to practice as a Professional Engineer or Professional Land Surveyor in the State of Mississippi. The duties performed by said Registrant shall conform to the definitions under the “practice of engineering” and practice of “land surveying” in Mississippi Law. The Contractor shall not engage the services of any person in the employ of the Department for the performance of any of the work covered by this Section or any person who has been employed by the Department within the past six months except those who have legitimately retired from service with the Department during this period.

All cross sections, measurements, and tickets required for determining pay quantities will be the responsibility of the Department.

The Department reserves the right to check for accuracy any or all of the Contractor's layout work and shall be assisted by the Contractor's personnel in such checking. When errors or discrepancies are found, the Contractor will take measures necessary to correct, at no expense to the State, any construction that has been performed using the improper layout. Any inspection, checking and approval thereof by the Engineer of work for which the Contractor is responsible will not relieve the Contractor of responsibility to secure correct dimensions, grades, elevations, alignments and locations of the work for satisfactory completion of the project and as a condition for final acceptance by the Department.

**699.04--Method of Measurement.** Construction stakes will be measured as a lump sum quantity. When Pay Item No. 699-A, Roadway Construction Stakes, is provided in the contract, measurement shall include the staking of all bridges,



including detour bridges, which are a part of the contract.

**699.04.1--Roadway Construction Stakes.** Measurement for payment will be in accordance with the following schedule:

- (a) When one percent of the original contract amount is earned from all direct pay items, 10 percent of the amount bid for Roadway Construction Stakes will be paid.
- (b) When five percent of the original contract amount is earned from all direct pay items, 25 percent of the amount bid for Roadway Construction Stakes will be paid.
- (c) When 20 percent of the original contract amount is earned from all direct pay items, 50 percent of the amount bid for Roadway Construction Stakes will be paid.
- (d) After the Contractor has earned 50 percent of the original value of all direct pay items, the amount paid will be based on the contract percent complete.

**699.04.2--Bridge Construction Stakes.** Measurement for payment will be in accordance with the following schedule:

- (a) When one percent of the original contract value of all bridge items is earned, 10 percent of the amount bid for Bridge Construction Stakes will be paid.
- (b) When five percent of the original contract value of all bridge items is earned, 25 percent of the amount bid for Bridge Construction Stakes will be paid.
- (c) When 20 percent of the original contract value of all bridge items is earned, 50 percent of the amount bid for Bridge Construction Stakes will be paid.
- (d) After the Contractor has earned 50 percent of original contract value of all bridge items, the amount paid will be based on the percentage of work completed on all bridge items.

**699.05--Basis of Payment.** Construction stakes, measured as prescribed above, will be paid for at the contract lump sum price, which shall be full compensation for completing the work.

Payment will be made under:

699-A: Roadway Construction Stakes	- lump sum
699-B: Bridge Construction Stakes	- lump sum